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CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

The Garonne, and the works executed upon it under the direction of M. BAUMGARTEN. By JOSEPH BENNETT, Esq.

(Continued from page 32.)

Vegetation upon Banks of River.—The banks are clothed with a beautiful vegetation. Among the trees, the willow growth is most abundant; then the poplar; and next the acacia and alder. The willow springs up spontaneously upon the gravel, sand, and slime; the wild willow called "brusquet" with dark green leaves has a spontaneous growth in the alluvium; the cultivated willow, with a white leaf and appearing like the olive in the distance, is planted by the proprietors for props to the vine; the osier, which serves for withes, is cultivated some distance from the shores.

As soon as the gravel banks emerge from mean water, the indigenous poplar appears upon them; it is quite crooked, with hard wood, and much in demand for mechanical structures. It is only suffered to grow in the rear of the tow-paths, as otherwise it would be subjected to the biennial clippings exacted by navigation interests. The white willow was used in the plantations within the works with most success.

Any slip set 1 or 1½ ft. in the ground will grow; shoots of one years growth are the best; though branches of 2 to 3 years growth, ·4 to 4 ins. diameter, are also planted; when set on high ground, their length

should be 2½ to 3 ft., and then the branch may be divided into 4 or 5 saplings. When planted on low ground, or even covered by low water, the head must be left above mean high water; they thrive in all seasons, if the earth is not too dry and parched, and are generally planted between September and May; for in those months the branches may be cut without injury to the trunk and the saplings are most fresh. Sometimes the plantings are made to intercept the silt of November, December, and January freshets, though those planted after the winter succeed the best. When planted to thrive and for profit, they are set 3 feet apart, but for collecting silt or protecting the shore bank they are set closer. The earth thus planted, and in good condition, yields as much as a similar amount with grain, and is called a "jetin."

They are distinguished into high and low cuttings; the trunks of the first grow from 8 to 11 ins. thick to 6½ ft. above ground, and the branches are not allowed to go above this height; they are spaced 6½ to 9 ft. apart; the trunks of the second do not grow over 2 ft. above the ground, with only 5 to 9 branches upon them.

In cultivation, the young branches are cut so that they may not absorb sap, and all shoots and leaves of principal branches are trimmed once a year. The only branches left are those destined to become what are termed "lattes," which are cut every two or three years, either for commerce, when only the lowest and thickest part of the stem is taken, or for wicker-work and plantations, when the full length with all small branches are preserved.

The "lattes" are of four qualities:—1st. Branches 27 ft. long reduced to 24½ ft. and 2 ins. diameter; 13 to the bundle. 2d. Length reduced to 21 ft. and 1½ ins. diameter; 25 to the bundle. 3d. 16½ ft. long, 1 in. diameter, 50 to the bundle. 4th. 11½ ft. long, ¾-in. thick, two bundles, 50 in each, a load for a man.

Upon the Rhine the cuttings are made every five years, for lengths of 15 ft. In Holland, seven to eight years are required for a less growth. Such is the advantage of a southern sun and the fertile soil of the Garonne.

Upon 4042 ares = 99·8 acres, in the Isles of Col-de-Fer and Cordès, the mean annual produce was 19,269·85 francs = $3588·4, and reckoning the hay with it, it would reach the sum of $3910.

The mean annual expense was 9680 francs = $1802. The net revenue is then $21·08 per acre.

No account is taken of the future profit arising from 3000 poplars, which border the walks and which will yield 1500 francs per annum, thus giving in all a net revenue of 320 francs per hectare, or $24 per acre.

We have dwelt upon this description under the conviction that the willow may be serviceable in protecting the banks of our own rivers, and on the supposition that it will here find a ready growth in wet gravel or sand.

We pass over the elaborate tables showing the importance of the navigation, and proceed to a general description of the works; which may be considered in three separate periods:—the first, before 1826, built simply for the protection of property, without regard to improve-

ments of navigation; the second, in which the system of M. Baudre was initiated, and in which many trials were made in concert with proprietors, who contributed a considerable part of the cost; the third beginning in 1836, comprising the works executed by the state, according to the type of M. Baudre, which had proved successful.

First Period.—The proprietors had, for a long time, defended the banks against corrosions by willow plantations, protected by lines of small stakes, driven by the sledge or beetle and inclined to the banks; they stayed, but did not prevent final destruction. In 1810, M. Vivens, a rich and energetic proprietor, undertook to secure his property, above Tonneins, from the ravages of the St. Germain gravel banks, by irregular lines, formed of strong pine piles secured with wicker-work and an enrockment, and cut at 3 ft. above low water; gradual advances were made into bed of river, thus involving the expense of fortifying the heads from time to time. Successful in this, he afterwards farmed the land above the rocks of Reculay, which was attacked by the gravel of the Sérénat bank, and was authorized in February, 1820, to make some improvements, for which he advanced $ 2200. Prior to this, there had been made eight wiers, each 22 yards long, 43½ yards apart, and inclined 45° to the shore, each costing about $ 200.

He hoped, by cutting a canal in the bank, to have the cut deepened by the water itself; but the freshet of February, 1823, filled it up, and carried away all the lines which directed the water upon it; and so he returned to the method of successive corrosions, by works gradually advancing from opposite banks, and was successful.

In December, 1823, a royal ordinance formed two syndicates of the owners of Coussan and Thivras, with power to make 2180 yards of defensive works each. The lines of wiers were inclined 65° to 75°, to the down-stream shore, and formed of pine piles driven 1·4 yards apart; they were wattled and cut 2½ ft. above low water; they were 54½ yards apart and jutted into river 27 to 33 yards from bank. Each line was connected with a shore line cut 3 ft. above low water. The head of the up-stream side was to be 5½ yards in rear of lines coming from banks, and to project 5½ yards beyond the head of the next lower, thus presenting a salient acute angle and a re-entering acute angle, whose purpose was "to retard the velocity, which, a line having the same curve as stream, would tend to increase and to bring destruction upon the enclosure." In building, this plan was changed so as to present a salient obtuse angle, its apex being 5·4 to 11 yards beyond the middle of a straight line connecting the two heads of lines from banks, or *connecting* lines. But the effect of this was to produce eddies, deposits, and injury to navigation. The willow branches filling voids of wicker-work, rose 1½ yards above low water in the connecting lines, and 2·2 yards in shore lines; there was but little enrockment for the piles, at the foot of which were grounded fascines not even filled with sand, and rising no higher than 3 ft. below surface of low water.

The ice-breaking of 1829 carried away these works, and the pro-

prietors, having to bear one-half the expense, were discouraged; of the $4927 charged to the Coussan syndicate, but $3797 were collected. The expense at Thivras was $3644. These were the principal works of the first period.

Works of the Second Period.—In March, 1828, M. de Baudre presented to the government his beautiful project for the complete restoration of the banks of the Garonne, and it was approved in September. Its successful execution, nearly without change, excites the admiration of all who pass through the valley.

For all the more or less inclined connecting lines, rising 2½ ft. above low water, he substituted throughout lines, normal to the new projected shore lines, rising 5 ft. above low water; for the irregular lines of enclosure and the salient and re-entering angles of Thivras and Coussan, he substituted two regular and nearly parallel lines from 590 to 656 ft. apart, so arranged as to contain the mean water, and with alignments and gentle curves, as near as possible to the channel, and designed to displace the least amount of gravel. His project, so different from any of the previous ones, comprised the development of the river in the two departments of the Lot-et-Garonne and the Gironde; but we have only to deal with that between the mouth of the Lot and the department of Gironde. In this extent of 31 miles, M. de Baudre thought that only where the expense was great the work should be done in concert with proprietors, and that otherwise they should be left entirely to the charge of proprietors.

He designed 15 partial projects with a development of 17·9 miles upon the right bank and 18·2 miles upon the left; the cost of the first establishment, irrespective of plantations and their maintenance, rose to $411,974, upon which he had counted for $181,492 to be contributed by proprietors in consideration of the benefits accruing to them, both in defences and in creation of new land.

With these conditions they were to enjoy possession of the alluvions, planting and maintaining at their own cost when delivered over to them by the state. As usual in such cases, it was only the intelligent and rational few who took an interest. But a new impulse was given, and no proprietor undertook aught outside of the proposed line, and the state granted aid to the works already made.

M. de Vivens executed one of these, the 16th in the order of classification of M. de Baudre; it had a development of 3 miles; the expense was estimated at $36,406, two-thirds of which was to be furnished by the state. He incurred the risk of all damage from high water, and engaged to maintain in good order all parts of the newly formed banks. All the works were completed in 1834. The enrockments were to have been 3 ft. below low water and at some points even with it; but generally they were carried from 3 to 6 ft. above it, and the greatest care was had for their maintenance.

We pass by the various other records of works of the second and third periods, some by the state, some by the proprietors, and some conjointly, whose object was, generally, to suppress secondary arms, to re-unite islands with the shore, to deepen shallows, and protect valu-

able lands; the improvements made for nearly 30 miles cannot be denied, even by those engineers opposed to the system, who think that they can be but partially realized, and at the expense of localities above and below them, having no faith in their durability.

System actually adopted.—It has been said that the lines are nearly parallel, from 574 to 590 ft. apart, except in sharp curves, where they may be 656 ft.; that they are connected with the banks by normal lines at distances from 262 to 328 ft., but which may be 130 to 160 ft. in violent currents. These connecting lines are simple or double; when the velocity is small, two or three single lines are substituted for the double lines, which generally alternate regularly with each other.

The height of shore lines has been constantly on the increase; in the first period, it was 3 ft.; in 1836, it was 6 ft.; in 1842, 8 ft. was adopted. This height is essential for a prompt formation of land, for in 1848 the works of 1836, cut at 6 ft., are, in this respect, far behind the works of 1844, cut at 8 ft. The connecting lines should be higher than shore lines—they are generally 1½ ft. higher—at first they were cut at the same level, except where secured to banks; there the plane of cutting was inclined a length of 16 to 33 ft., so that the last piles secured to bank were at its level.

These lines are formed of pine piles, 7 to 9 ins. thick, spaced 4½ ft., and driven with a hand rope pile driver 6½ to 8 ft. in the gravel; these piles are woven with willow, pine, or oak branches, forming a wicker-work, which is pressed down as low as possible, and always at least 3 ft. below low water mark. In the shore lines the heads of the piles are connected externally by a brace 5 to 6 ins. square, spiked level with their top or 8 ins. below; it protects wicker-work and unites piles.

The connecting lines are made of two parallel lines 3 to 5·3 ft. apart, with cross pieces spiked level, or a little below tops of piles; the space between is filled with gravel, and to prevent loss from undermining, one or several layers of fascines 8 to 10 ins. thick are put in the bottom, and the sides are interlaced with small willow branches. The end towards shore line is usually lined with rubble, sometimes a layer is put on top, and nearly always the surface of this coffer is covered with plantations of willow.

To consolidate shore lines, they are protected externally with rubble to 3 ft. below low water, with a slope of 45°. To economize rubble, which costs 96 cts. per cubic yard, a core is made of fascines, formed of willow or poplar branches filled with gravel, where the depths are over 6½ ft., and this is covered with rubble 5 to 6½ ft. thick. The interior of shore lines and the connecting lines are only consolidated with fascines raised 1·6 ft. below low water; for they are always covered with earth formations before time alters or destroys them.

It is sometimes necessary to consolidate the connecting lines at their establishment in the bank, by covering its upper portion with rubble immediately below the junction; this necessity is felt at the head of the works, especially when the connecting lines are unusually produced; when they project 160 ft. it is indispensable to cover the bank

immediately below the first four or five connecting lines, for a length successively diminished, which may be 16 ft. for the fifth, but should be 98 ft. at least for the first. As far as possible, the shore line should accord with the bank, and in case it is impossible, the end of the first connecting line, or the head of shore line, should be connected with the bank above by an inclined line.

To reduce the velocity of currents which pass above the piles, and to facilitate the deposit of sand and slime, the voids of the wicker-work are as closely packed as possible with willow branches, whose bottom reaches low water, and whose tops rise 13 to 16 ft. above it; in this unfavorable position they frequently thrive a year or two; this operation which hastens the earth formations is called "flocage."

The first winter generally yields a deposit 16 to 33 ft. below connecting lines, and the planting should be made as soon as there is a thickness of 15 to 20 ins. of sand; if the silt has but little consistency 2 to 2½ ft. is needed. In four years nearly the whole of the surface to be subdued may be planted.

Openings 6½ ft. wide are generally left in river lines, for the entrance of lighters, in which the plantings are made; but these should be closed when not in use, as they would allow entering and issuing currents, which retard the deposits, for the more the velocity is slackened the more rapid is their growth.

The closing up of secondary arms formed at the Isles of Cordès, Balias, Souilhagon, and Col-de-Fer, was generally effected by a prolongation of the single shore lines at the head and foot of the isles; but when these shore lines became true dams, as was frequently the case, they were made double, with enrockments exterior and interior, raised to height of cross pieces, and covered on top with rubble. The earth formations were usually so rapid as to do away with the necessity of intermediate dams, and only at Isle Souilhagon was a new dam made midway across, 14 ft. above low water, for checking the violence of high water.

It was thought best at first to leave openings both up and down stream, to facilitate the entrance of currents and gravel, but the up-stream openings were soon closed and the precaution was unnecessary. The lower openings were indispensable, for the outlet of such water as might find its way in these arms. The land formations first appear in front and rear of suppressed arms, and care must be taken not to plant immediately upon their whole extent; for then the banks would quickly form to a height of 13 to 16 ft. above low water, leaving the interior in the state of a marsh or pool. A space 60 ft. wide, both above and below, should be left free of all spontaneous growth, as it is the only way to prevent a too sudden uplifting of deposit.

When the shore line passes directly against a bank, or in the rear of it, piles are dispensed with, it being sufficient to excavate the bank a slope of 3 to 1, and covering it with rubble, with willow shoots at intervals; when the deposits have reached 13 ft. above low water, a tow-path may be constructed 50 to 60 ft. in rear of shore line, with a breadth of 13 to 16 ft. and a height of 16 to 18 ft.

Pile-Driving.—The curves are laid out very simply by stretching a cord between two piles, marking of its versed sine, or sagitta, then connecting this point with the ends and taking for sagitta ¼ of the first, and so on. The pile-driver is worked by 15 to 25 men, is mounted on a boat, and has a monkey weighing 330 to 660 lbs.; from 10 to 30 may be driven 6½ to 8 ft. in gravel, generally at a cost of 33 to 37 cts. per pile.

In a thin bed of gravel, or only in a bottom of tuffa, an artificial bed is made of fascines 2½ ft. diameter, 13 ft. long; the piles driven in these beds will resist ordinary currents until they are wattled and consolidated with rubble. At first they were all shoed, but experience shows that they enter the hardest gravel as easily if the ends are simply sharpened. Shoes are only indispensable where but a slight bedding in tuffa is desired. There are three kinds of piles: the first, 23 ft. long 9 ins. thick, costing $3·91 per cubic yard; the second, 19½ to 23 ft. long 7 ins. thick, at $3·27 per cubic yard; the third, 19½ ft. long 7 ins. thick, at $2·77 per cubic yard, stripped of bark and delivered on the spot.

Wicker-Work.—The waling rods, of willow, pine, or oak, are generally stripped of the small branches, or they may be wound round the main stem; the large end of a branch is let into the folded shoots of the other; they cross at every 6½ ft. and are bound at crossing by 4 withes. In all cases the big end is placed towards interior of shore lines and turned up stream; in connecting lines it is placed in the interior of the double lines and turned towards the bank. The hurdles and piles are interlaced like weaving, the piles the woof, the waling rods the warp; this is driven down as far as possible by several men jumping forcibly upon it. The wicker-work thus made costs 2½ cents per square yard.

The willow wicker-work is made from the two first choices spoken of; also those of oak and pine are divided into two classes: the first, 16½ ft. long 2 ins. thick; the second, 14½ to 16½ ft. and 1½ ins. thick. Here is a table of number of laths required for 109 square yards of wattling.

	First choice.	Second choice.	Total.
Oak, . . .	380	500	880
Pine, .	650	850	1500
Willow, . . .	500	750	1250

$18·60 a thousand is paid for first choice of oak or pine, and $11·16 for second choice.

Trials made of oak dating six years back, though in exposed positions, show them to be in good condition, while willow lasts but three to four years and pine four to five years; so that oak is now exclusively used for shore lines.

The space between the piles is filled with plantings, packed close as possible within wicker-work; it is termed "flocage," and is gene-

rally composed per running metre of 15 waling rods of willow third choice and 30 of the fourth with all their branches; in no case should their lower extremities be above low water; their height above top of piles should be at least 5 ft. They are protected against towing lines by pieces united to piles, which project every fourth pile 5 to 6½ ft.

The "flocage" of connecting lines is the most useful; they produce their effects in one year, so that plantings upon the alluvium may then take their place. In strong currents they are usually dispensed with in shore lines.

Enrockments.—For economizing rubble, fascines 2½ ft. diameter and 13 ft. long are most generally used upon shore lines; 37 to 43 cts. is usually paid per yard of gravel packed in fascines, in each of which there are eight fagots, made from trimmings of the state plantations and costing from $2·79 to $3·72; they are strongly bound at every foot with osier withes; 30 for each, costing $2·23 the thousand. A gang of four men make from 8 to 10 per day.

The small fascines are 10 ft. long 12 to 15½ ins. thick, and are used in rear of shore lines and below connecting lines; they cost $4·65 per one hundred, for fashioning, transportation, and sinking. In this quantity are 150 fagots of green, or 200 of dry wood, and they are bound with ten withes.

Outside of the shore lines these fascines are covered with rubble 3 ft. above low water and resist all currents. When the alluvium shall reach a height of 17 ft. above low water at 33 ft. in rear of shore lines, their slope should have 3 to 5 ft. base to 1 ft. height, and covered with a simple layer of rubble to avoid maintenance of wicker-work, which would be impossible when the piles are rotted.

Plantations and Questions of Titles.—The plantings are made, except at the inlet and outlet of secondary arms, as soon as the deposit has consistency for the growth of shoots, and quite often deposits covered by 6 to 10 ft. of water are planted, in preference to the lands lying above it; for though they do not prosper, yet they induce more rapid deposits. The plantings are often torn up or buried in gravel, and have generally to be renewed. Behind connecting and shore lines, and in the interior of inclosures, ribbons of saplings 5 to 6 ft. wide are planted close to each other, perpendicular to shore lines, solely to check the current and promote deposits.

For the preservation of the plantings between tow-path and shore lines, which are of vital importance to the works, the use of oxen and chains are forbid in the ascending navigation; the minimum height above the boats for attachment of lines is 10 ft., and they are to be fastened to the largest boat at head of convoy, six horses being allowed for each.

But for the towing interests, every two years between Nov. 1st and Dec. 31st, cuttings are ordered to be made on their borders.

The question naturally arises as to how much of bed of river belongs to the public, and as to the ownership of property created by the state works.

The proprietors, by no means eager to contribute towards the ex-

pense of these works, were still eager to enjoy the benefits resulting from them, and beside their hopes they brought their hatchets and bill hooks to the cutting of woods designed for the protection of the bank, under the pretext that all belonged to them as far as low water.

The administration put these two questions:—1st. How far does the water extend which forms the essentially variable limit between the bed of the river, or public domain, and private property? Is it low, mean, or high water, just before freshets begin, that should be taken for this limit? 2d. What is the competent authority to determine this limit?

A judgment of the tribunal de Nerac declares, in the absence of special legislation on this point, recourse must be had to the Roman law, where the bank is called that which incloses the river at its greatest height of water. "Ripa ea putatur esse, quæ plenissimum flumen continet." The power to determine this limit evidently belongs to the administration, who alone is charged with the preservation of rivers and all that regards the free running of streams.

In this case, an order of the Prefect prescribed a height of 5 metres on the Marmande scale as the limits in which the exclusive care of the engineers shall be given to the preservation and execution of all works necessary for the increase or consolidation of deposits designed to form new banks of river; whenever the bank surpasses that height it shall become private property.

Some such law was requisite to secure effectual and orderly methods of work. Experience in the commencement of the work had shown the danger of leaving these plantings to be made by the proprietors only.

The other works upon the Garonne relate to the maintenance of the tow-path, dredging of channel, and removal of rocks from bed of river.

The works of the tow-path consist of maintaining earth works at a height of 18 ft. above low water; the slopes are generally planted with willow, sometimes lined with fagots, and rarely with enrockments. They are often shifted, for, not being planted, the surface yielding to the trampling of horses' feet and hollowed out by currents, forms a ditch; in which case, the land adjoining, which has been raised by plantations, is used, and the old path is planted, and in the course of three or four years is ready to take its place.

Ten road-laborers, two navigation overseers, and a superintendent were specially charged with these works.

The bridges, wherever the tow-path is not over from 30 to 80 ft. from the rectified shore line, are generally made of oak with 15 ft. span; when not liable to a change of position they are made of beton of strong hydraulic mortar without any stone.

For trenches with small streams, earthen pipes 14 ins. diameter 1 in. thick, made at Toulouse and delivered at Marmande at $1·67 per running yard, are used. It is well to lay the two heads in enrockment to prevent rupture of extreme tubes.

The rocks are worked with great iron chisels, 14¾ ft. long and 4 ins. diameter, with steel edges, which are driven into the hard tuffa to de-

tach the fragments; they are worked with a pile driver mounted on boats. The front of the bank is cut away perpendicular to the required depth of excavation; the advance is up-stream, detaching portions 1½ ft. wide, allowing them to fall in the undermined parts; the smallest blocks are left to be carried away by the great freshets; the larger are taken out with claws; the excavation costs from $1·13 to $1·42 per cubic yard. In this way a channel was excavated across the Reculey rocks, 98 ft. wide 656 ft. long, where there is now a depth of 3 ft. at low water.

The complement of the works of rectification and the endykement of the mean water-bed would be the general endykement of the plain, or limitation of the larger bed, by means of two insubmersible earth levees, with sluices for introducing silt; it was thought that the minimum width between dykes should be 1968 feet, allowing small dykes in the interval, not over a yard high.

From a detail of expenses, there were used for each running yard of shore directly protected, 5·4 cubic yards of rubble, 0·517 cubic yards of pine, 5·3 lbs. of wrought or cast iron. The greatest expense was for enrockment, which came to $3·52 per yard; then the furnishing and use of piles, which came to $2·38. The wicker-work and interior planting (flocage), with their renewal till complete, cost $1·32; and about $1·70 was expended in fascines, filling of coffers, repairs of waste, and sundries. As a mean, $1·91 was expended for 119 square yards of plantation.

The advantages gained by these works to the proprietors were, 1st, the defence of the wooded banks; 2d, the creation of new lands; 3d, the security with which insubmersible dykes could be raised at a certain distance from banks.

The advantages to navigation were, in the regulation of the unequal slopes of surface, especially in low water; in the diminution of excessive velocities, which could not be passed without additional horses, and that without sensibly increasing the mean velocity.

The gravel banks or shallows, which always exist in rivers with shifting bottoms, were lowered, so that the minimum draft, which formerly at these passes was but 2½ ft., had attained a depth of 3·6 ft. wherever the works had produced their normal effect; the displaced gravel not obstructing or raising the bed of the river in the lower parts, but deposited in a stable manner, continuous with the banks, whose works have reduced excessive velocities in all stages of water: a unity of direction was imparted to the strongest currents, even until the time of freshets, and beyond these limits there was a power of controlling them with co-ordinate insubmersible levees.

Finally, wherever the bottom was assailable the works have produced a fall in the plane of low water, which fall compensates for the rise in the plane of ordinary freshets, which might be occasioned by the works, and so the fears manifested as to the greater frequency of freshets from contractions of the river, were groundless.

For the Journal of the Franklin Institute.

Bridge over the Theiss, and Tubular Foundations. By M. CEZANNE, Engineer des Ponts et Chaussées. Translated by J. BENNETT.

(Continued from page 14.)

PART THIRD.

Tubular Piers.—The general arrangement of a pier with two cylindrical columns and two square bodies is caused for the Theiss bridge by the necessities of construction, as shown by the drawings; but the choice of materials for the columns, their diameter, their distance apart, their setting up, the height of the separate pieces, the thickness of their sides, the arrangement of the joints, the interior filling, the external defences and modes of execution, are subjects which we propose to describe generally, and in the order specified.

Choice of Materials.—Cast iron was preferred to wrought iron for the cylindrical columns, because they were supposed to be less exposed to heat, and easier managed; still it had its inconveniences: at the bridge of Macon a cast iron column was broken by the shock of a boat; a cold snap in contracting the column upon the interior mass of masonry might cleave the metal. This inconvenience was avoided by forming the part of the column above the summer level in wrought iron segments, riveted to each other by means of exterior angle-irons, so that a broken or rusted segment might be replaced. Wrought iron was adopted for the square bodies, because it was better adapted than cast iron to the square forms and to the connexions with the arches.

Diameter of Tubes.—By increasing the diameter of the columns, the pressure upon the base would be diminished; but the volume of filling would be increased, and the difficulties of manufacture, and especially the sinking of the columns.

An attempt was made to procure at Szegedin the cylindrical drums in one piece, and the diameter of 9·84 ft. was chosen as the greatest made till that time, and because these pieces were to come from Scotland a special provision must be made for their transportation.

With these dimensions, the pressure uniformly spread upon the base was 104 pounds per square inch under the proof trial.

This pressure was raised to 199 pounds for that of the tubes of the Quarantaine bridge at Lyons, which bore the two middle girders.

The English have sunk columns of a greater diameter than 9·84 ft.

The barrels were formed of segments bolted to each other.

Below 6·56 feet, the work of the miner was difficult for want of space.

Distance apart of the two adjoining Columns.—3·28 feet was the least distance adopted between the two columns of the same pier, after a consultation with the English engineer having a personal experience of tubular foundations, and, during the construction, it was a matter of regret that a greater distance had not been chosen. A displacement of one column has occurred during the operations upon the adjoining one.

The Setting of the Columns.—In the sinking of the columns, re-

gard was had rather to the possible underminings than to the nature of the soil, which continued the same for a great depth. A mean sinking of 19·68 ft. would have been sufficient; a greater depth was adopted for security, and they were usually stopped at about 65·6 ft. below high water, so that they should not be exposed to a pressure of three atmospheres, beyond which the work was very painful to the men.

Height of Barrels.—The height of a column being determined, it remained to decide upon that of the different barrels.

It was for the interest of the work to increase the height to lessen the number of joints; but the founder and transportation agent insisted upon manageable dimensions; 5·95 ft. was adopted.

These drums weigh 12,100 pounds. They were obliged to appropriate for their transportation between Scotland and Germany a special steamboat, and to establish at the point of their arrival at Harbourg, on the Elbe, some fixtures for their removal.

Thickness of the Cylindrical Sides.—When the cast iron columns are only exposed to vertical pressures, calculation indicates that a slight thickness only is needed for the support of the entire bridge; but the founders refused to cast pieces of a thickness too small for the diameter. For this reason, at the bridge over the Great Pee-Dee in America, the engineer was led to the adoption of 1·96 ins. thickness for tubes of 5·97 feet diameter, answering to a resistance 650 times greater than was required.

For the Theiss bridge, it was admitted to be difficult to make regularly tubes of 9·84 ft. diameter with a less thickness than 1·18 ins.

Moreover, it was admitted from experiments made in England at the Viaduct of Tarascon, that cast iron might be subjected to a permanent transverse load equal to $\frac{1}{6}$th of that of rupture, say 6285 lbs. per square inch, for the castings required in this case.

The thickness 1·37 ins. was calculated in regard to this maximum, by considering the column as supported at its two ends, loaded upon its head with the weight Y, and acted upon transversely at the height of the springing by the difference X between the horizontal thrusts of the arches which it bore.

The dispositions of the final plan furnished the following data, in the most unfavorable case for the stability of the pier, or that in which one of the two adjacent bays is charged with 5365 lbs. per running foot, while the other is free.

We have for a single column: Y = 367,400 lbs.
X = 360,800 "

a, the distance between the point of application of the force X and the head of the column, where the top stringers of the arches are made fast to the column, equal to 18·93 ft.

b, the remainder of the height of the column to the head of the interior piles, equal to 65·37 ft.

R,	the work relative to X	per square inch,	5657	lbs.
Q,	" " Y	"	728	"
R + Q,	" "	compression,	6385	"
R — Q,	" "	tension,	4929	"

The value R — Q is the maximum of efforts of tension produced by the trial loads; it is much less in practice since the usual loads over the road are much below that of the trial proof; because only one track is loaded at a time, and the struttings of the arches and the connexions with the square bodies tend to distribute between the two tubes the reactions of the arches.

In the conditions of the contract the proportions of the castings were not determined, but it was required that bars of prescribed dimensions should be cast at each tapping and subjected to direct experiments.

Experiments were made in this way upon 442 bars in breaking them by a transverse loading,—they had a section of 1·57 ins. by 1·3 ins.; their mean resistance was 30 k. 4 per square millimetre or 43,428 lbs. per square inch.

The maximum was 52,285 lbs.; the minimum, 29,000 lbs., occasioned by a fault in the casting at the point of fracture.

The resistance required by the contract was 37,143 lbs.

Upon the testing of the bridge, the most unfavorable case for the stability of the piers was chosen by loading each span with 5365 lbs. per running foot, all the other spans being free, and the following laws were observed.

All the piers deflected at the level of the springing lines in separating from the loaded span.

The two piers next the loaded span as a mean deflected 0·157 in.; the two piers at the distance of one span deflected 0·059 in.; these deflections diminished rapidly with their distance from the loaded span; they were sensible, though they could not be measured from one extremity to the other of the bridge.

The depressions at the summit of the spans, which were but 0·472 in. when all the bridge was loaded, attained 1·18 ins. for the single loaded span, which is explained by the increase of the cord; the two adjacent spans rose from 0·196 to 0·236 in.; the following to ·078 in. at most; further on no motion was detected.

The usual locomotive trains were passed over the two tracks with great speed, either side by side, or in opposite directions: this trial did not give any maximum for the deflections of the trusses or that of the piers.

Arrangement of the Joints.—The method of jointage is shown in Pl. I., Fig. 3, where we see the bearing or turned surface upon which the two barrels are brought in contact, the jointing which prevents their sliding, the bands or flanches which receive the one the head, the other the nut, of a bolt, which fastens them, and the ribs or brackets which unite the flanch with the cylindrical part. A tight joint is made by iron filings cement tamped with a graver between the two flanches. The ribs are badly contrived, at least under the flanch, which at the foundry is placed at the upper part of the mould; they form there recesses in which the gas bubbles lodge, thus producing blisters. It would be advisable to suppress the ribs, to increase the thickness of the flanches, and the radius of the roundings of the jointage.

The cement was composed as follows:—

Iron filings,	1000	parts in weight.
Sal almoniac,	10	"
Flowers of sulphur,	2	"
Water for dissolving the salt.		

This mixture would set in two days during the summer, in eight days during the winter; it was then worked with the file and smoothed, but became impaired in moist air.

For the iron filings cement, was substituted at the bridge of Bordeaux an india-rubber cord let into a groove, simplifying the joint, and economizing in time and manœuvring.

The two adjoining flanches of the Theiss bridge were fastened by 48 bolts, 1·97 ins. diameter, which would be much too strong were these columns but to bear the simple weight of the bridge, and these bolts designed but to fasten the joint; whereas, these columns had to resist transverse thrusts, and accordingly it became necessary to fortify the joints as much as possible. The most exposed, that of the square body with the cast iron capital, was secured with 72 bolts.

Calculation applied to the joints of the circular barrels, gives for the maximum load per square inch of strain of bolt 6528 lbs., or even 16,025 lbs., according as we suppose the neutral axis to be at the centre of the circular joint, or at the circumference.*

We should reduce the number of bolts to the strict necessity of the case, to simplify the jointage, and to facilitate the tamping of the mortar, and 8, 12, or 16 bolts of 1·18 ins. will generally be sufficient.

Interior Filling.—The beton serves to give mass to the columns, and to distribute their weight upon the entire base. Usually it bears the platform directly; in that case, the metallic covering is a sort of coffer dam. At the Theiss bridge, the columns with other duties to fulfil, have their solidity with the beton insured by the following arrangements:—

The square wrought iron body surmounting the cast iron column, and upon which the arches abut, is strengthened within by two strong girders, PP, of double T iron (Pl. I., Fig. 2), which connect the two opposite faces, and sustain them against the thrust of the arches.

Beneath these girders is a brick and cut stone masonry, which crowns the beton and bears the large iron wedges driven forcibly under the girders. This square body receives and transmits to the cast iron column the weight of the superstructure and its loads; and it cannot sink without bearing with it the interior girders, the masonry, and the beton.

The beton being perfectly contained in its metallic envelope, its quality is not a matter of importance.

It is said that a bridge has been constructed in America whose columns are filled with sand. If we go to the expense of beton, it is naturally desirable that it should set; now, some observations seem

* The neutral axis is in reality between these two positions; it may be found by a rigorous calculation, but we are led into transcendental equations, whose solution is laborious.

to prove that the setting of the beton in the tubular columns does not depend solely upon the quality of the beton itself.

When, with a view of rebuilding the column at Macon, which, as we have said before, was broken by a boat, it was found in demolishing it that the beton, quite hard at the upper part, became more and more soft as the bottom was approached. At the Theiss bridge, the lower barrel of a column of the first pier had been broken by the interior piling; after repairing it, it was proposed to fill this and the barrel above it with a mass of Portland cement, in which the head of the piles might rest, so that the foot of the column in case of loss of broken drum, might be none the less firmly established.

After having laid carefully many cubic yards of cement mortar at the bottom of the column, it was found that the setting was far from being as rapid as that in open air, and if the work was stopped a few hours, the lower parts became filled with water, which could clearly be seen to be disengaged from the mortar itself.

This observation and that at Macon induced the belief that one of the conditions of the setting of hydraulic mortars is that they should absorb the water, so as to retain the quantity exacted by the chemical reaction of solidification. This condition is far from being fulfilled in the tubular piers, which are air-tight, and it is possible that the most hydraulic betons may never set in them. An attempt was made to avoid this evil by mixing with the beton a certain quantity of fragments of dry bricks; it was thought that these porous materials might drain the mass of its excess of water. This possibly hazardous theory seemed, however, to be confirmed by the following experiment: the first pier of the bridge, founded in detestable earth, occasioned uneasiness from the commencement of the work. The down-stream column was the first constructed; it was loaded with 580,800 lbs. of rails for the trial proof; it sunk 1·53 ins. The up-stream column, whose foot was broken, and where brick was introduced in the beton, was proved in the same manner, and only sunk 0·18 in. This result could not be attributed to the cement mortar, which did not occupy the sixth of the total height of the interrupted masonry.*

The beton of the columns is generally commenced with a plugging in cement from two to three feet thick, for the purpose of closing the bottom of the column against the entrance of water occasioned by a momentary stopping of the air-pump, and by a diminution of the pressure. This precaution was not necessary at Szegedin, where it was determined in the execution of the work to sustain the foot of the columns by an interior piling, which by pressing the foundation rendered it perfectly staunch.

This piling (Pl. I., Fig. 2) is composed for each column of twelve spruce piles driven to a refusal of 5·9 ins. for 10 blows of a 2200 lbs. ram, falling 19·68 ft. It is admitted that each of these piles may bear about 50 tons each. The whole load to be borne with that of the trial proof was 1,144,000 lbs.†

At the general proof of the bridge, the sinking observed upon the

* See note B, upon a machine for making beton. † See in note C some remarks upon piling.

piers was from ·08 to ·12 in. The two columns of the first pier already proved, each sunk ·12 inch more. All the columns supported the test weight for twenty-four hours; some during thirty-six hours: frequent observations were made upon them, and it was remarked that after twelve hours of loading the sinking had nearly stopped.

External Defences.—The piers of the Theiss bridge were protected against undermining by a circuit of piles, a mass of beton, and by enrockments, for the purpose of strengthening the foot of the piers, and for diminishing the leverage of the transverse thrusts of the arches.

The breaking up of ice and the drifting boats are kept clear of the pier by a timber ice breaker, presenting to the current an inclined edge strengthened with iron, and spreading towards the pier so as to cover its whole width without resting upon it.

Modes of Execution.—The barrels of the Theiss bridge were cast in Glasgow, and brought in a rough state to Szegedin; they were turned and pierced in the workshop of the bridge.

The lathe was formed of a horizontal platform, upon which was placed the barrel, accurately centred and turning with it. Two tools fixed in a mass of masonry and provided with the means of adjustment, planed the two surfaces at the same time.

From twelve to fifteen hours were required to prepare a tube.

The drilling was done with the usual machinery; two drills, working simultaneously, pierced 96 holes in 30 hours, including the time of fitting up.

It was only after a trial made of two consecutive tubes placed on each other, that they were carried to the scaffolding of the pier.

These scaffolds were composed of five frames, spaced 13·12 feet apart. There was then in the inner gallery of the scaffolds four compartments of 13·12 ft. by 16·4 ft.; two for the columns, and two, one on the up-stream, the other on the down-stream side, serving as depots; the side galleries formed by the inclined braces afforded passage to and fro. The service bridge was connected with the up-stream compartment; upon the crown of the scaffold, one or two windlasses were worked upon a car.

These scaffolds had the serious inconvenience of not affording sufficient room around the columns, and of yielding too easily to the inclinations of their guides.

The landing of a column upon the bottom of the river was an interesting operation. There were two processes. When the water was shallow and the scaffolds high, the column was constructed upon a temporary platform placed as low as possible; then, being seized at the head by the windlasses, it was allowed to descend. When the water was deep and the scaffolds failing in height, which was the case at Szegedin, the operation was two-fold; a first part of the column was lowered and hung upon long iron hooks, whose heads were raised above the water and fastened to the scaffold. Upon this base, nearly all submerged, was raised the remainder of the column, which was then lowered entire.

A wrought iron cross-bar with three branches took hold of the upper flanch of the top barrel through six bolt holes. This was suspended to a wrought iron beam which balanced the action of the two windlasses.

The column weighs 66,000 lbs.; there are eight men at each windlass; each block has 4 sheeves and a fall of 1·97 inches.

The second process consists of fitting a wooden bottom to the lower barrel, and in floating the column; it is well in this case to reserve the means of moderating, and, at need, of stopping, the entrance of the water, so as to have full control of the column during its establishment.

A column weighing 30 tons thus placed upon the bottom of the river, never sinks more than a few centimetres (cent. = 0·39 in.) if the soil is of gravel or compact clay; though in a bottom of sand and mud some of the columns have sunk 3·28 ft.

Before placing the pneumatic fixtures upon the column, care is taken to instal upon the flanches of the upper joint, that separating the first drum from the second (Pl. I., Fig. 4), a flooring, a windlass and its chain, some pieces of wood, shovels, picks, &c., and generally all thematerials whose dimensions do not admit of being passed through the air chamber: at the same time, the water syphon tube is located by being attached to the different flanches.

Pneumatic Bell. (Pl. I., Fig. 4.)—The pneumatic receiver is a cylindrical drum of rolled iron of the same diameter as the cast iron column, open at the bottom, and closed on top by a flooring or roof. The lower circular edge is provided with an angle-iron pierced with holes corresponding with those of the upper flanch of the column. A strip of india-rubber being placed between the receiver and the column, all that is needed for the joint is, to bolt strongly the flanch and the angle-iron.

The roof of the receiver is traversed by two bodies, M M, nearly cylindrical, of cast iron, in a vertical direction, having about two-thirds of their height within the receiver, and the remainder jutting beyond it.

These two similar and independent cylinders form each an air chamber, which may be closed at the top by a circular valve opening inwards, and turning upon a horizontal hinge; and at the bottom, by a vertical rectangular door, cutting the cylindrical body parallel to its edges, opening round a vertical hinge from the interior of the chamber towards the interior of the column. The door and valve are lined with strips of india-rubber. Different pipes and cocks, D, allow communication between the interior of the air chamber with the exterior of the reservoir or with the atmosphere; these tubes are manœuvred either by men placed under the receiver upon the interior flooring, or by those placed under the air chamber, or by those on the outside.

The remaining apparatus consists of two valve fixtures, to which are applied two air tubes, communicating with the pumps by a safety valve, a metallic manometer (Bourdon's), two other valves affording a rapid escape of the interior pressure, a bend of a syphon, with a cock

upon the inside. All these contrivances are fitted to the cylindrical sides of the reservoir, which also supports a series of brackets, upon which are placed the cast iron counterweights.

These counterweights are of cast iron segments, whose form is adapted to the contours and projections of the bell. They are united to each other in pieces of 11,000 lbs. weight. With some modifications in the form of the brackets, the ordinary rails may be used.

The air and syphon tubes are of iron, and have on one side a collar, and on the other a wormed mouth-piece (Pl. I., Figs. 5 and 6). The collar of the one pipe enters the mouth-piece of the other, and the latter turns independently of the pipe which bears it, so that the joints can be tightened without dismounting the pipe. Some india-rubber joints give a pliability to the system needed to follow the motions of the boats and those of the columns.

(To be Continued.)

MECHANICS, PHYSICS, AND CHEMISTRY.

Description of Aerts' Water Axle-box. By Mr. Sampson Lloyd.

From Newton's London Journal, April, 1861.

The attention of engineers and carriage builders has been constantly directed to improvements in railway axle-boxes, as shown by the various contrivances that have been invented for the purpose. These, however, have all included the use of oleaginous matter as a lubricator, though it is well known there is an inherent defect attached to such a material, since the brass bearing must be heated, by the friction of the journal, before the grease can be brought down to lubricate the bearing. If a perfect lubricator for railway axles could be obtained, it would effect a great saving both of tractive power and also of commercial cost, as compared with a material that performs its duty in an imperfect manner. The essential conditions for a good method of lubrication are,—first, a constant and abundant supply of a pure lubricating fluid; and, secondly, the working parts should be always kept free from foreign substances, the tendency of which is to increase the friction, or to intercept the free contact of the lubricating material with the bearing surfaces. These conditions are successfully fulfilled in the simple construction of axle-box now about to be described, which is the invention of M. Aerts of Belgium,—the principal feature being the use of water as the lubricator, in place of oil or grease which has generally been used on railways, thus avoiding the many inconveniences that have resulted from the use of fatty substances.

On the end of the axle a cast iron disc is firmly fixed, working in a reservoir of water. When the carriage moves, the disc, turning round with the axle, raises the water by the centrifugal force of its rotation into the upper part of the axle-box, where it is caught by a brass scraper, resting loosely on the top of the disc, and is discharged

into the inclined spout, which conducts it directly over the axle, and thus lubricates the bearing completely and continuously. The lubrication thus commences as soon as the carriage is put in motion, and the quantity of water lubricating the bearing is increased in proportion to the velocity of rotation, since the faster the disc turns, the greater is the quantity of water carried up with it.

The joint at the back of the axle-box is made by a cast iron collar, keyed on the axle immediately behind the journal; it is turned accurately on the outside, and runs within a leather collar that is made to be just a fit upon it; this leather collar is riveted inside an annular cast iron disc, and is kept always close upon the collar by the slight pressure of a small india-rubber band or steel spring surrounding it. To prevent leakage of water between the leather and the cast iron collar, where the friction takes place in the running, the flanch of the collar is made of a conical form, and the inner side of the annular disc is similarly shaped, so that, by the rotation of the collar, the water is thrown away from the joint by centrifugal force, and returned into the axle-box. The disc is held up against the back of the axle-box by an outside back plate, and has a thick india-rubber ring let into a groove in its face, which presses against the back of the axle-box and forms a water-tight joint; allowing for the box coming down as the brass wears, and at the same time affording sufficient elasticity to admit of a slight play of the disc within the space at the back of the box whilst running. When the axle-boxes are well fitted, and the joint at the back properly made, there is no leakage of water, and the level of the water does not perceptibly vary during a long time of running, since that which has lubricated the axle returns into the reservoir in the lower part of the box; and the amount of evaporation of the water is in practice so small as to be scarcely appreciable.

With the ordinary method of lubrication, if an axle gets heated, it is cooled by throwing water on it; but in the water axle-box, the water, being poured over the axle in a continuous stream, effectually prevents it from heating. Water has also the advantage of allowing all solid particles to sink to the bottom of the reservoir; but where grease is used, these remain mixed with it, and thus become the chief source of wear and heating of the bearing. To clean the reservoir, it is only necessary to unscrew a plug in the lower part of the box, which allows the dirty water to run out; and by means of a syringe, such as is used in cleaning the carriages, the reservoir can be thoroughly rinsed through; the screw is then replaced, and a supply of fresh water poured into the box through the lid. This process is, therefore, neither difficult nor expensive in the water axle-box; while with the ordinary grease box, when it gets out of order, the carriage must be raised and the bolts of the box unfastened, which requires considerable time and the attendance of several workmen. If the reservoir should accidentally be omitted to be filled with water, or if, by any means, the water should run out of the box, there is still an ordinary grease box as a reserve to fall back upon, which will come into use on an emergency, the upper part of the box containing a

supply of grease like an ordinary axle-box; but as the waste of water is so very small, such a case is not likely to occur when proper care is exercised.

When applying this method of lubrication by water to the bearings of shafting, the disc for raising the water, as the shaft revolves, is made in two halves, fastened together by lugs, and fixed on the shaft by a set screw or key; the water carried up is caught by a scraper, which discharges it direct upon the top of the bearing.

Before fixing the water axle-boxes in place, the brass bearing and axle are both well greased, so as to prevent oxidation of the metal by the water; while the water prevents the contact of the two metals as it passes between the two greased surfaces. In practice, the grease is found to solidify after a short time of running, and forms a sort of varnish of a dark brown color, thus proving the absence of actual contact between the two metal surfaces; for were it otherwise, the surface of the axle would become polished.

This water axle-box was tried on the Great Northern Railway during the early part of the year 1860, on a second class carriage having two of the bearings fitted with the water box and two with the ordinary grease box used on that line. The result of five weeks running over a total distance of 9819 miles was, that the brass bearings of the water axle-boxes were not found to be diminished in weight, while the bearings of the grease boxes had lost together 4½ ounces; and the water boxes ran 7326 miles without requiring to be replenished with water. Trials of the water axle-boxes have also been made on the Eastern Counties Railway during the past and present years: the two bearings of one axle in a first-class carriage of an express train were fitted with the water axle-boxes, and those of the other axle with the ordinary grease boxes; after running a total distance of 11,249 miles during two months constant working, the brasses in the ordinary boxes had lost together 30 ounces in weight, while those in the water boxes had lost together only 7 ounces, or less than one-fourth; the wear of the brasses occurring principally at the shoulders of the bearings. The consumption of grease in this trial was 8½ lbs. in the two ordinary axle-boxes, and in the water boxes 3 lbs., which, however, was all consumed on one journey and in one box, in consequence of the box having been, by neglect, allowed to run without water on one occasion; but no inconvenience was occasioned, as the tallow in the reserve grease chamber was quite sufficient to lubricate the bearing in the absence of the water. In a subsequent trial on another first-class carriage, during two months constant running, the water axle-boxes worked remarkably well; they ran for many days a distance of 252 miles daily, without requiring additional water, and were not supplied with any grease after that originally put in.

By this method of using so simple and perfect a lubricating material as water, the cost of oil or grease is saved, and it is calculated that a considerable saving of traction results from the almost total absence of friction, while the wear of the brasses and journals is reduced to a minimum; so that instead of the brasses lasting on the

average only nine months, as is ordinarily the case, their time of running is greatly increased.

Mr. Lloyd showed a specimen of the water axle-box for railway carriages, and a model of its application to bearings of shafting. He had brought the subject forward because his experience of the axle-box had been very satisfactory, as regarded its application both to railway bearings and to shafting revolving at a rapid rate; and improvement in lubrication was of great importance, particularly for the axles of railway carriages, where the present cost of grease and renewal of brasses formed such a large item of expense. At Mr. Leech's mill at Staleybridge, where the water boxes had been applied, there was a large shaft that previously caused great difficulty by heating, and required oiling two or three times during the day; but by applying the water boxes, the shaft had now been running more than a year, without any heating taking place, and no trouble had been experienced with the bearings; they continued working quite satisfactorily, the grease having formed a varnish over the bearing surfaces.

Mr. Aerts explained, that the principle of lubrication by means of water was not a new one, it having been previously used for stationary bearings in mills, as in the case of the bearings of rolls; but in such instances, the water was employed in a current running over the bearing to keep it cool, and was all allowed to run away.

He further said, it was desirable to allow a slight leakage of water at the leather collar where the friction took place, in order to insure the leather being kept always moist. It was possible to run 1000 miles without any fresh supply of water to the box; but in practice it was advisable to replenish the boxes with water every day, or after running 400 or 500 miles. For emptying the water quickly out of the axle-box, the hole at the bottom of the box was now closed by an india-rubber washer, held up by a spring instead of by a screwed plug; this saved time and trouble, and avoided the use of tools. The handle of the spring came up in front of the box, and had a slot in it, so as to be readily fixed open for the water to run out, or closed securely when a fresh supply had been poured in.—*Proc. Mech. Eng. Soc.*, Aug. 9th, 1860.

Experiments to Determine the Properties of some Mixtures of Cast Iron and Nickel. By WILLIAM FAIRBAIRN, F. R. S.

From the Lond. Chemical News, No. 52.

Some of my chemical friends in London had got an impression, from a careful analysis of meteoric iron, that it could be produced artificially by the combination of some of the same elements that were found to exist in the specimen analyzed, containing about 2½ per cent. of nickel.

In order to determine whether it would be possible to obtain an artificial compound of this nature, and to ascertain the effect produced

by mixing a certain proportion of nickel with cast iron, the following experiments were instituted. They consisted, in the first instance, in the extraction of the nickel from the ore which is found in the mines of the Duke of Argyle, near Inverary, in Scotland. The metal having then been purified by repeated meltings, was mixed with cast iron in such proportions as to form a compound, containing the same quantity of nickel as the specimen analyzed. This was done by melting 2½ per cent. of nickel with carefully selected South Welsh cast iron from the works of Blaenavon and Pontypool. The mixtures were fused in crucibles, and run into ingots or bars, which were then tested in regard to their mechanical powers of resistance to a transverse strain.

This was done with great care, and the results which follow give unmistakeable evidence of the effects produced upon cast iron by an admixture of nickel, however small the quantity of the latter that may be introduced. Meteoric iron is, above all others, the most ductile, and it is recorded by travelers that the Esquimaux have instruments made from this description of iron so ductile that they may be made to bend round the arm. The ingots prepared on the occasion of these experiments were, however, widely different, as their power to resist impact was nearly one-half less than in those composed of pure iron.

It is uncertain what might have been the results had the castings produced been treated as cast steel, and hammered out until they were rendered malleable and magnetic. This process was not, however, attempted, as, judging from the appearance of the fracture, they were more likely to crumble under the hammer than attain malleability.

The nickel for these experiments was prepared from the ore, by fusing at a very high temperature in a crucible or steel pot,

30 lbs. of roasted ore,
5 " fine sand,
2 " charcoal,
2 " lime.

This mixture was kept in the furnace six hours, and then taken out and allowed to cool. The metal was then separated from the slag, and again melted with half its weight of roasted ore and one quarter its weight of green bottle glass ground to powder.

As before, the mixture was kept for six hours, at the temperature of a cast steel furnace. The metal had by the end of that time collected at the bottom of the crucible. It contained about 25 per cent. of nickel, and was of sufficient purity to be fused with cast iron. 10 lbs. of it melted with 112 lbs. of cast iron gave a mixture containing about 2½ per cent. of nickel.

The object of these fusings was to reduce the metallic oxide by means of the charcoal, while the lime and sand removed the oxide of iron, silica, sulphur, and other impurities by forming a fusible slag.

Mixtures of nickel with cast iron (No. 1) and Blaenavon iron (No. 3) and Pontypool iron, each containing about 2½ per cent. of nickel,

and also some pure Blaenavon cast iron (No. 1), were cast into bars about one inch square, and two feet six inches long, and subjected to the following experimental tests.

(A table showing the breaking weight and deflections of the bars when subjected to a transverse strain is here given in the original. Want of space obliges us to omit it. The results reduced from it are given in the following table.)

TABLE I.—*Results reduced to bars 1″ square. Distance between the supports 2′ 3″.*

	Breaking weight (b).	Ultimate deflection (d).	Power of resisting impact ($b \times d$).	Strength compared with Blaenavon = 1000.
Experiment I. Bar D, pure Blaenavon No. 3, ...	1131	0·75	848·2	1000
Experiment II. Bar C, Blaenavon No. 3 and nickel, . . .	875	0·58	507·5	773
Experiment III. Bar B, pure cast iron No. 1, ...	861	0·47	404·7	761
Experiment IV. Bar A, cast iron No. 1 and nickel, ...	637	0·434	276·4	563
Experiment V. Bar E, Pontypool iron and pure nickel, ...	798	0·366	292·1	705
Mean, . .	860	0·52	465·7	760

From the above, it is evident that an admixture of nickel in the proportion of 2½ per cent. does not increase, but diminish, the tenacity of cast iron. To what extent it might be improved by augmenting or lessening the proportion of nickel, a more extended series of experiments alone can determine. Mixtures of the two metals in the proportion used in the above experiments are decidedly inferior to the pure metal in their power of resistance to a transverse strain and to impact. In the first and second experiments on Blaenavon iron there is a loss of nearly one-fifth the strength; or the strength of the pure metal is to that of the mixture as 1000 : 773. And in experiments III. and IV., with a more fluid iron there is about the same loss, the relative strengths being as 761 : 563; or as 1000 : 740. From these facts, it is evident that nickel in the proportion of 2½ per cent. seriously injures the strength of cast iron, and, moreover, has injurious effects on its power of resisting impact, as the columns in the above table indicating those properties clearly show.

It is difficult to account for the serious deterioration and loss of strength which the above experiments indicate. It may probably arise from the improper treatment of the nickel ore during its calcination and subsequent reduction in the crucible. When cast into ingots after the second melting, the nickel had not the appearance of a pure metal, but exhibited a dull fracture, as if fine sand or particles of earth had been mixed with the crystals, showing the presence of

impurities which it would be almost impossible to get rid of. It remained, therefore, a question for consideration whether the results would be different if nickel, properly prepared and of greater purity, were employed. To clear up doubts on this point, a mixture of pure nickel with No. 3 Pontypool iron was made, but the result was a bar of white silvery metal, which broke when the weight of 798 lbs. was laid on, as will be seen by reference to the tables above.

I obtained from London a number of other bars, consisting of iron and nickel, which, on being submitted to the same tests as before, gave better results than those obtained in the previous experiments when nickel prepared from the ore was employed.

The results obtained from this second series of bars are given in the following table:—*

TABLE II.—*Results reduced to bars* 1″×1″. *Distance between the supports* 2′ 3″.

	Breaking weight (b).	Ultimate deflection (d).	Power of resisting impact ($b \times d$).	Rates of strength Bar F 2 = 1000.
Experiment VI. Bar F 1 without notches, . . .	867	0·315	273	1000 : 876
Experiment VII. Bar F 2 without notches, . . .	989	0·38	376	1000 : 1000
Experiment VIII. Bar G 1 with one notch, ...	760	0·331	231	1000 : 768
Experiment IX. Bar G 2 with one notch, ...	899	0·41	368	1000 : 908
Experiment X. Bar H 1 with two notches, . . .	746	0·286	213	1000 : 754
Experiment XI. Bar H 2 with two notches, . . .	703	0·29	203	1000 : 810
Mean, . .	829	0·335	280	1000 : 838

I have been unable to ascertain the precise composition of these bars: but, assuming it to have been similar to that of the first series of bars, the greater powers of resistance shown by them would seem to indicate that the nickel employed in their preparation possessed a higher degree of purity than that used for the first series. Much, however, depends on the quality of the cast iron with which the nickel is mixed. The results derived from the foregoing experiments are conclusive, both in regard to those made on the first and those made on the second series of bars. Further experiments may, however, lead to different results; but, judging from what has already been done, I am inclined to believe that chemical combinations of a different nature are required, and probably a totally different process of manufacture will have to be adopted before a sufficiently strong and satisfactory compound can be obtained.

* The table is omitted as before, the results alone being contained in the table given.

In attempting to ascertain the effect of a mixture of nickel with cast iron, the principal object was to determine to what extent the compound gave positive or negative results. It is well known that meteoric iron is peculiarly ductile, and it was assumed that nickel, added to cast iron in such proportion as to produce a compound similar to meteoric iron, would impart to it increased ductility. The foregoing experiments lead, however, to the conclusion that an admixture of nickel, produces an exactly opposite effect, and it now remains to be determined, by a more extended series of experiments, whether by mixing nickel with malleable iron in the same relative proportion more satisfactory results would be obtained. In prosecuting these experiments, it would be interesting to know the extent to which these metals are capable of combining chemically, how closely such combinations would approximate to meteoric iron.

Besides endeavoring to obtain a metal of greater ductility, another object of equal importance was aimed at in these experiments, namely, to produce a metal of increased tenacity suitable for the casting of cannon and heavy ordnance. During the last two years, innumerable experiments have been made for this purpose, with more or less success; but the ultimate result appears to be, that for the construction of heavy artillery there is no metal so well calculated to resist the explosion of gunpowder, as a perfectly homogeneous mass of the best and purest cast iron, when freed from sulphur and phosphorus.—*Memoirs of the Literary and Philosophical Society of Manchester*, vol. xv.

Nomenclature of Printed-Stuffs.

M. Chevreul read to the French Academy of Sciences a memoir on the distinctions which would give the most perfect security to commerce as to the stability of the colors on stuffs, without interfering with the freedom of business. In place of the vague and useless distinctions now adopted, he proposes the following: *very stable*, *stable*, *moderately-stable*, *changeable;* expressed in numbers, or in the degrees of the chromatic scale which the prints lose after one, six, or twelve months exposure to the light and air. There is but one very stable color, that is, *indigo* applied by M. Chevreul's process, by passing through steam. *Indigo* applied by the old process is merely stable: *Cochineal* and *Madder* with certain mordants are stable; with other mordants they are only *moderately-stable*, as is *Weld* (*reseda-luteola*). *Brazil* and *Campeachy-woods* are moderately-stable. *Annotta* (*bixa orellana*), *Turmeric*, and *Safflower* are changeable.

M. Chevreul regrets that certain new colors, such as *muroxide*, *orcëine*, *fuchsine*, *azalëine*, which are very beautiful and agreeable to the eye at first, but very changeable, should have been over-praised of late, at the expense of the old and stable colors, indigo, cochineal, weld, which will remain alone or nearly alone in the manufactories when their rivals have disappeared.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 46.)

Hollow Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.—Low Moor Iron, No. 2.

Length or height in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated breaking weight in tons from formulæ, $b = 46{\cdot}65\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$ $T = \frac{bc}{b + \frac{1}{2}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	24	5	4	127·84	31·96	12·78
"	20	6	5	189·36	47·34	18 93
"	17 1-7	7	5½	359·07	89 76	35 90
"	15	8	6½	463·84	115·96	46·38
"	13 1-3	9	7½	574·13	143·53	57·41
"	12	10	8½	687·32	171·83	68 73
"	10 10-11	11	9	1033·95	258·48	103 39
"	10	12	10	1190 64	297·66	119 06
"	9 3-13	13	11	1349·25	337·31	134·92
"	8 4-7	14	12	1508 89	377·22	150·88
"	8	15	12½	2037·59	509·39	203·75
"	7 1-2	16	13½	2239 80	559 95	223 98
"	7 1-17	17	14½	2436 66	609·16	243·66
"	6 2-3	18	15½	2641·49	660·37	264·14

Table showing the Breaking Weight of Solid Uniform Cylindrical Pillars for different qualities of Cast Iron, Both Ends being Flat and Firmly Fixed, and the Safe Weight of same if Irregularly Fixed.

Height of pillar in ft.	Diameter in inches.	*For the Breaking Weight if Firmly Fixed.* Co-efficients for the strength in lbs., 78,400	89,600	100,800	112,000	123,200	134,400
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
8	2	11·95	13 66	15·36	17·07	18·78	20·49
10	2	8·17	9·34	10·51	11·68	12·85	14 02
10	3	34·50	39·43	44·35	49·28	54·21	59 14
12½	3	23·61	26·98	30·35	33·72	37·10	40·47
12½	4	65·56	74·92	84·29	93 65	103·02	112 38
15	4	48·08	54·95	61 82	68 69	75 56	82·43
15½	5	100·42	114·76	129·11	143·45	157·80	172·15
17	5	85 82	98·09	110 35	122 61	134·87	147·13
17½	6	156·07	178·37	200·66	222 96	245·26	267 55
20	6	124·37	142·14	159·91	177·68	195·45	213 22
		For the Safe Weight if Irregularly Fixed.					
8	2	1·19	1·36	1·53	1·70	1·87	2·04
10	2	0·81	0·93	1·05	1·16	1·28	1·40
10	3	3·45	3·94	4·43	4·92	5·42	5·91
12½	3	2·36	2·69	3·03	3·37	3·71	4·04
12½	4	6 55	7·49	8 42	9·36	10·30	11·23
15	4	4·80	5·49	6·18	6 86	7·55	8·24
15½	5	10·04	11·47	12·91	14·34	15·78	17·21
17	5	8·58	9·80	11·03	12·26	13·48	14·71
17½	6	15·60	17·83	20·06	22·29	24·52	26·75
20	6	12·43	14·21	15·99	17·76	19·54	21·32

In Mr. Hodgkinson's edition of Tredgold's Practical Essay on the Strength of Cast Iron, &c., page 26, a table is there given, entitled "A Table to show the weight or pressure a cylindrical pillar or column of cast iron will sustain, with safety, in hundredweights." This table was calculated by the following formula:—

l = length in feet, d = diameter in inches, w = weight to be supported in lbs.,

$$\frac{9562\,d^4}{4\,d^2 + \cdot 18\,l^2} = \text{w}.$$

The following table is an abstract from Mr. Tredgold's, with this difference: the original is given in hundredweights, and I have reduced it to tons. A note attached to this table by Mr. Hodgkinson, says: "This table has no solid basis. The very ingenious reasoning from which the formula is deduced by which the table was calculated, depends upon assumptions which Mr. Tredgold was induced to adopt through want of experimental data. See Mr. Barlow's Report on the Strength of Materials, 2d vol., of the British Association."

Table from Tredgold, reduced to Tons.

Diameter in inches.	Length or height,							
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
2	3·00	2·45	2·00	1·60	1·30	1·10	0 90	0·75
2½	5·25	4·55	3·85	3·25	2·75	2·35	2·00	1·70
3	8·15	7·25	6·40	5·55	4·85	4·20	3·65	3·20
3½	11·60	10·70	9·55	8·60	7·80	6·75	5·95	5·30
4	15·50	14·40	13·30	12·10	11·00	9·90	8 90	8 00
4½	20·00	18 95	17 70	16·35	15 05	13·75	12·55	11·45
5	25·05	23·95	22·60	21·35	19·70	18·25	16·85	15·50
6	29·60	28·65	27 50	26·25	24·85	23·45	22·00	20·65

Table from my calculations, being One-Twelfth of the Breaking Weight as deduced from Mr. Hodgkinson's formulæ for Solid Pillars of Cast Iron with Flat Ends.

Diameter in inches.	Length or height,							
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
2	2 04	1·25	0·85	0·63	0·48	0·38	0·31	0·26
2½	4·52	2·77	1 89	1·39	1·07	0·85	0 69	0·58
3	8 23	5·30	3·62	2·66	2·04	1·63	1·33	1·11
3½	13·21	9·16	6 27	4·59	3·53	2·82	2·30	1·92
4	19·71	14·19	10·07	7·38	5·68	4·53	3·70	3·10
4½	27·80	20 43	15·30	11·22	8·63	6 88	5·63	4·70
5	37·56	28·13	21·64	16·31	12·55	10·00	8·18	6·84
6	62·23	48 21	38·00	30·55	23·98	19 11	15·64	13·07

Table from my calculations, being One-Fourth of the Breaking Weight as deduced from Mr. Hodgkinson's formula for Solid Pillars of Cast Iron with Rounded Ends, and from calculations based on other of Mr. H.'s formulæ.

Diameter in inches.	Length or height,							
	6 ft.	8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
2	2·39	1·47	1·00	0·73	0 56	0·45	0·37	0·30
2½	5·42	3·40	2·32	1·70	1·31	1·04	0·85	0 71
3	9·82	6·75	4 62	3 39	2·60	2·07	1·70	1·42
3½	15·75	11·45	8·25	6·05	4·66	3·71	3·04	2·54
4	23·62	17·58	13·47	10 00	7·69	6 13	5·02	4·19
4½	33·30	25·39	19·79	15·58	11·98	9·55	7 82	6 53
5	44·86	34·99	27·71	22·36	17·81	14·19	11·62	9·71
6	73 63	59·70	48·71	40·19	33·59	28·18	23·05	19·28

Table from my calculations, being One-Twelfth of the Breaking Weight as deduced from Mr. Hodgkinson's formulæ for Solid Pillars of Wrought Iron with Flat Ends.

2	3·62	2·03	1·30	0·90	0·66	0·50	0·40	0·32
2½	6·96	4·50	2·88	2·00	1·47	1·12	0·88	0·72
3	11 95	8·20	5·50	3·82	2·80	2·15	1·69	1 37
3½	18 57	13·17	9·51	6·60	4 85	3·71	2·93	2·37
4	26·92	19·65	14·59	10·61	7·80	5·97	4·71	3·82
4½	37·00	27·72	20·96	16·13	11·85	9·07	7·16	5·80
5	48 85	37·46	28 83	22·49	17·22	13·18	10·42	8·44
6	77·83	62·09	49·28	39·35	31·79	25·19	19·90	16·12

Table from my calculations, being One-Fourth of the Breaking Weight as deduced from Mr. Hodgkinson's formula for Solid Pillars of Wrought Iron with Rounded Ends, and from calculations based on other of Mr. H.'s formulæ.

2	4·02	2·26	1·44	1·00	0·64	0·50	0·40	0·36
2½	8·39	5 23	3·34	2·32	1·70	1·30	1·03	0·83
3	14·86	10·11	6·65	4·62	3·39	2·60	2·05	1·66
3½	23·61	16·66	11 88	8 25	6·06	4·64	3 66	2·97
4	34·75	25·33	18·78	13 63	10·01	7·67	6·06	4·90
4½	48 30	36·27	27·43	21·23	15 60	11·94	9 43	7·64
5	64·27	49·55	38·28	29·95	23·18	17·75	14·02	11 36
6	103·39	83·28	66 69	53·61	43·52	35·23	27·84	22·55

Mr. Hodgkinson gives the following formulæ for the breaking weight of solid cylindrical pillars, both ends being rounded, and the length of the pillars exceeding 15 times their diameters:

For cast iron, $$W = 14{\cdot}9 \frac{D^{3.76}}{L^{1.7}}.$$

For wrought iron, $$W = 42{\cdot}8 \frac{D^{3.76}}{L^{2}}.$$

In the following tables for cast iron pillars with rounded ends, and in succeeding tables for wrought iron pillars with rounded ends, it will be seen how far I have made use of Mr. Hodgkinson's formula, withholding for the present the formulæ I have used for those pillars below 30 diameters.

Tables showing the calculated breaking weight and safe weight of uniform solid cylindrical pillars of cast iron, both ends being rounded or irregularly fixed.

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $w = 14{\cdot}9\frac{b^{3{\cdot}76}}{L^{1{\cdot}7}}$.	Safe weight in tons.
5	30	2	13·05		3·26
6	36	"		9·59	2 39
7	42	"		7·38	1·84
8	48	"		5·88	1·47
9	54	"		4·81	1·20
10	60	"		4 02	1·00
11	66	"		3·42	0 85
12	72	"		2·95	0·73
13	78	"		2 57	0·64
14	84	"		2·27	0 56
15	90	"		2·02	0 50
16	96	"		1·81	0·45
17	102	"		1·63	0·40
18	108	"		1·48	0 37
19	114	"		1·35	0·33
20	120	"		1·23	0 30
5	24	$2\frac{1}{2}$	26·93		6·73
6	28 8	"	21·70		5·42
7	33·6	"		17·06	4·26
8	38·4	"		13·60	3 40
9	43 2	"		11·13	2·78
10	48	"		9·30	2·32
11	52·8	"		7·91	1·97
12	57·6	"		6·82	1·70
13	62 4	"		5·95	1·48
14	67·2	"		5·25	1·31
15	72	"		4·67	1·16
16	76·8	"		4·18	1·04
17	81·6	"		3·77	0 94
18	86·4	"		3·42	0·85
19	91·2	"		3·12	0·78
20	96	"		2·86	0 71

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $W = 14{\cdot}9\,\frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$.	Safe weight in tons.
5	20	3	47·53		11 88
6	24	"	39 29		9 82
7	28	"	32·60		8·15
8	32	"		27·03	6·75
9	36	"		22·12	5·53
10	40	"		18·49	4·62
11	44	"		15·73	3·93
12	48	"		13·56	3·39
13	52	"		11·84	2 96
14	56	"		10 43	2·60
15	60	"		9·28	2·32
16	64	"		8 31	2·07
17	68	"		7 50	1·87
18	72	"		6·81	1 70
19	76	"		6·21	1·55
20	80	"		5·69	1·42
5	17·142	3½	75·32		18 83
6	20 571	"	63·00		15·75
7	24	"	53·56		13 39
8	27·428	"	45 81		11 45
9	30·857	"		39·50	9 87
10	34 285	"		33 02	8·25
11	37·714	"		28·08	7·02
12	41·142	"		24 22	6·05
13	44 571	"		21·14	5·28
14	48	"		18 64	4·66
15	51·428	"		16 57	4·14
16	54 857	"		14·85	3·71
17	58 284	"		13 40	3 35
18	61·714	"		12 16	3·04
19	65 142	"		11 09	2 77
20	68 571	"		10·16	2·54
5	15	4	110·57		27·64
6	18	"	94 50		23·62
7	21	"	81·23		20·30
8	24	"	70·32		17·58
9	27	"	61·32		15·33
10	30	"	53 88		13 47
11	33	"		46·40	11·60
12	36	"		40 02	10 00
13	39	"		34·93	8·73
14	42	"		30·79	7·69
15	45	"		27·38	6·84
16	48	"		24·54	6·13
17	51	"		22 13	5·53
18	54	"		20·08	5·02
19	57	"		18·32	4·58
20	60	"		16·79	4·19

Solid Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated breaking weight in tons from other formulæ.	Calculated breaking weight in tons from formula, $w = 14{\cdot}9\frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$.	Safe weight in tons.
5	13 333	4½	153·57		38·34
6	16	"	133·20		33 30
7	18 666	"	116·05		29·01
8	21·333	"	101 58		25 39
9	24	"	89 08		22 27
10	26·666	"	79·17		19·79
11	29·333	"	70·50		17 62
12	32	"		62·32	15 58
13	34·666	"		54 39	13 59
14	37·333	"		47 95	11 98
15	40	"		42·64	10·66
16	42 666	"		38·21	9 55
17	45·333	"		34·47	8 61
18	48	"		31 28	7 82
19	50·666	"		28·53	7·13
20	53·333	"		26·15	6 53
5	12	5	203 72		50·93
6	14 4	"	179 44		44 86
7	16 8	"	158 24		39·56
8	19·2	"	139 96		34·99
9	21·6	"	124·28		31 07
10	24	"	110 86		27·71
11	26·4	"	99·35		24 83
12	28·8	"	89 46		22·36
13	31·2	"		80·83	20 20
14	33·6	"		71 26	17 81
15	36	"		63 38	15 84
16	38·4	"		56·79	14 19
17	40·8	"		51 23	12·80
18	43 2	"		46·48	11 62
19	45·6	"		42·40	10 60
20	48	"		38 86	9 71
5	10	6	326·77		81·69
6	12	"	294 55		73 63
7	14	"	265·17		66·29
8	16	"	238·83		59 70
9	18	"	215 47		53 86
10	20	"	194 86		48·71
11	22	"	176·74		44·18
12	24	"	160·79		40 19
13	26	"	147 03		36·75
14	28	"	134·38		33·59
15	30	"	123 44		30 86
16	32	"		112·72	28 18
17	34	"		101 68	25 42
18	36	"		92·20	23·05
19	38	"		84·16	21·04
20	40	"		77·13	19·28

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{l^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $T = \frac{be}{b + \frac{1}{6}c}$.	Safe weight in tons.
8	9 3-5	10	8½	545·46		764 06	191·01
9	10 4-5	"	"	613 64		718 68	179 67
10	12	"	"	681 83		675·32	168 83
11	13 1-5	"	"	750·01		634·29	158 57
12	14 2-5	"	"	818 19		595·70	148 92
13	15 3 5	"	"	886 37		559·62	139·90
14	16 4-5	"	"	954 56		525 98	131·49
15	18	"	"	1022 74		494 73	123·68
16	19 1-5	"	"	1090·92		465·73	116·43
17	20 2-5	"	"	1159·11		438·85	109·71
18	21 3-5	"	"	1227·29		413 98	103 49
19	22 4-5	"	"	1295·47		390·92	97·73
20	24	"	"	1363 66		369 56	92·39
21	25 1-5	"	"	1431 84		349 78	87 44
22	26 2-5	"	"	1500 02		331·43	82 85
23	27 3-5	"	"	1568·20		314·41	78 60
24	28 4-5	"	"	1636·39		298 60	74·65
25	30	"	"	1704 57		283·90	70 97
26	31 1-5	"	"	1772·75		270·22	67 55
27	32 2-5	"	"	1840 94	254·44		63 61
28	33 3-5	"	"	1909·12	239 18		59·79
29	34 4-5	"	"	1977 30	225 32		56·33
30	36	"	"	2045·49	212 70		53·17
8	8 8-11	11	9½	604·43		883 38	220·84
9	9 9-11	"	"	679 98		836·33	209 08
10	10 10-11	"	"	755 54		790 80	197·70
11	12	"	"	831 09		747 17	186·79
12	13 1-11	"	"	906·64		705 67	176 41
13	14 2 11	"	"	982 20		666·44	166·61
14	15 3-11	"	"	1057 75		629·50	157 37
15	16 4-11	"	"	1133 31		594·84	148 71
16	17 5-11	"	"	1208 86		562·39	140·59
17	18 6-11	"	"	1284·41		532 06	133·01
18	19 7-11	"	"	1359·97		503·77	125 94
19	20 8-11	"	"	1435 52		477 36	119 34
20	21 9-11	"	"	1511 08		452 74	113·18
21	22 10-11	"	"	1586·63		429·79	107·44
22	24	"	"	1662 18		408·38	102·09
23	25 1-11	"	"	1737·74		388·41	97 10
24	26 2-11	"	"	1813 29		369·77	92·44
25	27 3-11	"	"	1888 85		352·36	88 09
26	28 4-11	"	"	1964 40		336 09	84·02
27	29 5-11	"	"	2039·95		320·86	80·21
28	30 6-11	"	"	2115·51		306 60	76·65
29	31 7-11	"	"	2191 06	292·36		73 09
30	32 8 11	"	"	2266·62	275·98		68 99

(To be Continued.)

On the Application of the Decimal System of Measurement in Boring and Turning Wheels and Axles. By Mr. JOHN FERNIE, of Derby.

From Newton's London Journal, June, 1861.

In a former paper, the writer stated some of the advantages to be derived from the application of the decimal system of measurement to various descriptions of mechanical engineering work, amongst which was the securing of wheels on their axles. In ordinary railway practice, the wheels are pressed on the axles by the hydraulic press, the wheel boss being bored so much smaller than the axle, that a certain amount of tension is put on the boss, such as experience may have shown to be safe. But this amount has always been empirical, and vaguely designated as a bare 16th, or a full 32d of an inch; and nothing could more forcibly show the necessity of a new system, than the measurement of the actual dimensions of the gauges hitherto in use, in which it has been found that the degree of tightness, or the difference in diameter between the wheel boss and the axle, ranged from ·003 to ·012 inch. The writer's object has, therefore, been to fix standard sizes for boring and turning, so that uniformity may be attained; and with this view, a number of trials were made.

The first step was to make two gauges, one 6·000 inches, and the other 5·988 inches long: to the larger of these an axle was carefully turned, and to the smaller, a wheel carefully bored; the difference of diameter being thus, ·012 inch: the wheel was then pressed on the axle, and again pressed off. There was considerable difficulty in pressing it off; three men, on a long lever, putting on a pressure of at least 80 tons; and it was only after some violent blows of a sledge-hammer that the wheel made the first start: after a few such starts, it came off easily. After being pressed off, the condition of the axle end, as well as of the boss, led to the conclusion, that an excessive strain had been applied, injurious to both wheel and axle; this appeared more fully on measurement. The axle was reduced ·002 inch in diameter, for nearly a third of the length in the wheel, and ·001 inch at the middle of the length, whence it gradually tapered off to its original size; the surface of the axle was also cut, though it had been well oiled before pressing the wheel on. The boss, on a careful measurement, was found to have sustained a permanent stretch, amounting to ·006 inch, and was slightly taper, and also slightly cut like the axle.

It was considered that the degree of tightness required was one that would not inflict any permanent injury on the wheel or axle; and in order to determine the amount, further experiments were made. In the fifth experiment, with a difference in diameter amounting to ·003 inch, and with the wheel very carefully bored and the axle very carefully turned, the wheel was pressed on and off without the boss retaining any permanent stretch, or the axle sustaining any injury. In addition, however, to great care in the boring and turning, it is necessary to get very smooth surfaces; for, in some of the trials made, it was found that when the wheels and axles were turned with a narrow-pointed tool, leaving the surfaces slightly rough, the tops of the sur-

faces or threads were ground off, and they would not stand pressing on or off so well as when they were turned very smoothly. The greatest difficulty in working to such small dimensions consists, not in the want of skill of the workmen, but in the roughness of the present machinery: some lathes have a strong bias to run taper, and some run slightly oval; there may also be some want of uniformity in the nature of the material, hard places to grind away the tool, or to press harder against it, and so make it work taper or oval. For these reasons, although ·003 inch appeared to be sufficient difference in diameter in the best work, the writer was ultimately led to adopt ·005 inch, the result of which is, a small permanent stretch of the wheel boss; but this is compensated for by the contraction of the tyre, which throws a considerable amount of compression on the boss. With ·005 inch difference in diameter, the wheel is pressed easily on the axle with a pressure of about 20 tons; and the permanent stretch, as measured in a number of wheels tried, amounts to from ·001 to ·002 inch. As it is almost impossible to secure a perfectly parallel hole through the boss, the lathe should be so arranged that the largest size is the entering side of the wheel; and if properly managed, a good fit from end to end of the hole may be obtained.

In securing the outside cranks on the axle ends, it has been found by experiment, that, instead of an allowance for shrinkage, amounting to ·030 inch on a diameter of 6 inches, ·015 inch is amply sufficient; and in pressing cross-head spindles of 2·5 inches diameter into their place, a difference in diameter of ·004 inch is sufficient; while levers with 3-inch holes require a difference of ·001 inch, when they are to be driven on with a lead hammer.

From a lengthened experience of this decimal system of measurement, the writer is more than ever satisfied of the importance and practicability of carrying out Mr. Whitworth's excellent system into the workshop: workmen soon learn to work to the fine measurements, and no difficulty has been experienced in this respect. Gauges, such as are used for standard sizes, are made in the ordinary way from standard end measures, by which the gauges in use can be verified, or new ones supplied at any time. For axle turning, the gauges are of steel, of the old horse-shoe shape, and are allowed to drop over the axle by their own weight; for wheel boring, they are made of flat steel, with the ends bluntly rounded over, and are made to pass through the boss with an easy pressure. There is no difficulty in working with these gauges to one-thousandth of an inch. Standard gauges for wheels and axles, levers, and shafts, made by Mr. Whitworth's measuring machine, can be obtained, giving the difference in size, as above described; and these need not go into the workshop, but can be kept for reference, others being made from them for ordinary wear and tear in the turning shop; and thus standard sizes may be got and kept, which will be of great value.

The decimal measuring machine constructed by the writer at the Midland Railway Works, Derby, and employed for producing the various standard gauges for use in the workshops, is similar in principle

and construction to Mr. Whitworth's measuring machine described at a former meeting of the Institution; the principle of its construction being that of end or contact measurement instead of line measurement, depending on the sense of touch instead of sight.

The machine consists of a strong and heavy cast iron bed, long enough to take in a measurement of 100 inches, and having a right-angled V groove in the top surface, in which the gauges to be measured are laid. At either end are adjustable centres. One centre is advanced or drawn back by an adjusting screw and nut, the latter being held stationary in the end of the bed, and turned by a hand-wheel of 10 inches diameter. The adjusting screw is made with, as nearly as practicable, 10 threads per inch, and the circumference of the hand-wheel, which is 2 inches wide, has a spiral line chased upon it, of rather more than ten turns; a standard inch bar is placed in the machine, and adjusted by a gravity piece in the manner afterwards described; and the position of the centre which receives its adjustment from the hand-wheel, is marked by a line against an index on the first turn of the spiral. The standard bar being then removed, the centre is advanced by the screw through the interval of 1 inch left vacant by its removal, and the position again marked by a line on the last turn of the spiral. The spiral is then carefully divided between these two marks into 10 equal parts, each of which is one revolution of the hand-wheel nearly, and corresponds exactly to ·1 or $\frac{1}{10}$th of an inch motion of the centre: each revolution of the spiral is then subdivided between the divisions previously obtained into 100 equal parts, so that each interval on the circumference of the hand-wheel represents accurately ·001 or $\frac{1}{1000}$th of an inch motion of the centre. By this plan the difficulty and expense of obtaining a screw having exactly 10 threads per inch, are obviated in a simple manner; any small excess or deficiency in the pitch of the screw being thrown into the spiral line on the hand-wheel, the correct graduation of which is accurately obtained from one of the standard inch gauges. In order to prevent any play in the nut, through which the screw works, it is made in two lengths, which are set together on the screw. The back centre is merely held tight by friction, by the grip of a wrought iron strap cottered to the bed; so that in case the hand-wheel should be turned round too far, the back centre will give way, and prevent the measuring screw from being injured by a strain: it is fitted with a small screw for the purpose of approximately adjusting the length of the groove in the bed.

For making a duplicate of any standard gauge by the measuring machine, the standard gauge is laid in the groove of the bed, and the distance to the back centre is made up with bars of convenient length. The measuring screw and centre which it operates are then advanced gradually by the hand-wheel, until the gravity piece, on being lifted by the finger at one end, remains suspended between the ends of the standard gauge and centre, the pressure being just sufficient to support its weight; and the corresponding graduation on the hand-wheel having been noted against the index, the centre is slacked back and the standard gauge removed. The proposed duplicate is then placed

in the machine and tried by means of the gravity piece; and its length is very carefully reduced by grinding the ends, with successive trials in the machine, until the gravity piece is again just supported between the duplicate gauge and the centre with the same reading on the hand-wheel as previously; when the length of the duplicate is known to be accurately the same as that of the original standard. The graduation on the hand-wheel affords the means also of producing gauges differing by any required amount from the standard gauges. Thus the gauges previously described, for boring the wheel bosses of 5·995 inches diameter, are made from the standard gauge of 6 inches length, by subtracting five divisions from the reading on the hand-wheel; so that the measuring screw has to be advanced ·005 or $\frac{5}{1000}$ths of an inch further before the gravity piece is held suspended.

The standard gauges used in the machine are steel bars one inch square, with the edges beveled off; the ends are made conical and reduced to a circle of $\frac{1}{4}$-inch diameter. A single 1-inch standard is sufficient for producing by the machine all the longer standards that are required, by making first another 1-inch standard, then a 2-inch standard from these two placed together end to end, and so on in succession; and the machine is long enough for measuring any length up to 100 inches.

Mr. C. W. Siemens said it was highly gratifying to see that such great accuracy had been carried out in work on a large scale as had been explained, and he was confident it would well repay any extra trouble by the superior quality of work obtained and the facility for renewal. Mr. Whitworth had rendered most important service by introducing the system of accurate decimal measurement; but he did not think the inch adopted by him as the unit of measurement was the most eligible, and it might become necessary at a future time to go over the question again in order to adopt a universal standard amongst civilized countries. It was a general opinion of the International Decimal Association that the only chance of getting a universal measure was to adopt the metre, which was convenient for use in this country, being nearly the length of the present yard; while the millimetre was generally the smallest size wanted for the workshop, being $\frac{1}{25}$th of an inch (·039 inch). The metre was now becoming the unit in many tables and calculations, and he regretted that another unit should be established in this country. He doubted whether $\frac{1}{1000}$th of an inch could be worked to in practice, and thought the gauges employed would be affected to that amount by difference in temperature.

Mr. C. Markham observed that the inch had been adopted as the standard, not on account of any intrinsic superiority over the metre, but because it was not practicable to carry out the metre system in this country, and the metre had lately been found to be a scientific fallacy as regarded its supposed perfection as a standard. Mr. Whitworth had adopted the inch as the standard on account of its universal application in the workshops and in all mechanical operations in this country. There did not appear to be any probability of getting the decimal system of measurement into use in this country except by

adopting for the standard the inch already recognised and in general use, so that the introduction of the decimal subdivision involved no change of measure. The improvements that had taken place in the construction of machines, and the remarkable truth and accuracy with which work was now executed, rendered it essential for the progress of mechanical science that $\frac{1}{1000}$th of an inch should be readily appreciated in the workshops by ordinary workmen. The Whitworth and Enfield rifles were bored out to $\frac{1}{1000}$th of an inch, and workmen soon became accustomed to work with extreme accuracy and truth. With the decimal system much greater accuracy was obtained than with ordinary fractions, by employing the sense of touch on Mr. Whitworth's plan of end or contact measurement, by which smaller dimensions than $\frac{1}{1000}$th of an inch were readily appreciated; and, in practice, it was required to have the means of expressing dimensions down to $\frac{1}{1000}$th of an inch, as illustrated by the results given in the paper just read. Different descriptions of wheels required to be bored out with slightly different allowances in the diameters; a solid cast iron wheel requiring to be bored out larger than a wheel with a light boss and spokes; and this difference could be readily measured and worked to by the decimal system with the use of gauges in the manner that had been described.—*Proc. Mech. Eng. Soc.*

On the Value of Different Kinds of Soap. By R. Graeger.

From the Lond. Chemical News, No. 68.

Complaints of consumers in regard to the value, or rather efficacy, of samples of soap, which to the best of the manufacturer's knowledge have been well prepared, are not uncommon.

It is very probable that the usual explanation which is offered, whenever a soap fails to fulfil the expectations of its consumer, viz: that it contains too much water, may be in many cases correct. Admitting this, and various other contingencies, which are of importance in deciding upon the value of a soap, there appears to be another obvious reason why different soaps containing equal amounts of water may still possess different degrees of efficacy.

It is evident from the different equivalent weights of the various fatty acids, that the amounts of caustic alkali taken up by them in the formation of soap must be of unlike magnitude.

If it be true, that the detergent power of soap is entirely dependent upon the amount of alkali which it contains, of course it follows that those soaps which contain the largest proportion of alkali,—or in other words, those containing a fatty acid, the equivalent weight of which is small,—must be the most efficacious.

Since the difference between the equivalents of the common fatty acids is not large, these considerations are, perhaps, of little or no importance in so far as concerns the consumption of soap in household economy—the total amount used in a single family being but small. In a manufacturing establishment, however, where fifty or a hundred

thousand pounds of soap may be used in the course of a year, differences which cannot be deemed insignificant must exhibit themselves.

For example, the equivalent weights of several soaps (regarded as anhydrous), in common use, are as follows:—

Oleic acid (red oil) soap,	.	= 3800·95
Palm oil	"	= 3588·85
Tallow	"	= 3300·95
Cocoa-nut oil	"	= 3065·45

Calculating from these weights how much of each of the other soaps would be required to replace 1000 pounds of tallow soap, the following quantities will be found:—

1151 lbs.	of oleic acid soap,	*i. e.*,	15·1	per cent.	more than	tallow soap.
1087 "	palm oil "	*i. e.*,	8·7	"	"	"
928 "	cocoa-nut oil "	*i. e.*,	7·2	"	less	"

Differences like these must certainly be of importance in practice; and could, doubtless, be detected by direct experiment, if any one would undertake a comparison of the various kinds of soap—a research which would not be easy, however.—*Bœttger's Polytechnisches Notizblatt.*

Artesian Well.

The *Cosmos* announces the final success of the artesian well which has been sunk at Passy near Paris for the purpose of furnishing the water for the artificial rivulets of the Bois de Bologne. The bed of water was met at a depth of 577 metres (1893 feet) on Saturday at 4 o'clock, A. M., and on Sunday it had risen to from 6 to 9 feet below the surface. The slowness of its rise is caused by the tube being choked with sand, which, however, is supposed not to come from any caving in of the sides or bottom of the bore.

On Boilers and Boiler Plates. By Mr. Ramsell.

From Newton's London Journal, June, 1861.

The author remarked, primarily, that twenty years experience in the construction of steam boilers had given him some practical knowledge of his subject, and that, therefore, he had little diffidence in speaking upon it. He had long ago become convinced of the necessity of adopting a different principle to that usually acted upon in the manufacture of boilers; and a very important point was to do away with "stays," as used for strengthening them. More especially, he referred to marine boilers, and instanced, in the following order, three principal evils attending the employment of stays: 1st, the obstruction they offered to the effectually cleaning of the boilers; 2d, the increased amount of incrustation induced by them; and, 3d, the water and steam space they occupied. The fracture of the steel boilers of the *John Penn*, S. V., which came especially under his notice last year, prompted him to give more consideration to the subject. In those

boilers, the number of stays rendered necessary by the thinness of the plates, made it almost impossible to clean them out, while the cracking of the plates at the sides of the fire-boxes completed their ruin. The steel boilers were, eventually, and after a very short trial, removed from the *John Penn*, and their places were supplied by iron ones.

Having witnessed this, and many other instances of the evils of stays, Mr. Ramsell stated, that he had come to the conclusion that iron plates for boilers might be so prepared as to give them strength, to a great extent, without adding to their thickness, or much to their weight. This object he proposed to effect by producing corrugations or indentations of any shape in the middle of each plate, and leaving plain surfaces on their outer edges, for the purpose of riveting them together. Plain surfaces for manholes, and the attachment of pipes, would also be left where necessary. The corrugations or indentations might be made by rollers or presses, as found most desirable or applicable to the particular size or shape of the boiler to be made. He had provided and used both rollers and presses for the purpose, and had experimented upon the plates produced by them. One series of experiments he would give them the details of, they having been made in the presence of Mr. Miles, of the firm of Humphrys and Tennant:

Two plates, made from $\frac{3}{8}$-inch bowling iron plate, the centre of the plates being only $\frac{1}{4}$ inch thick. Length and breadth from centre to centre of rivets, 5 feet by 3 feet 4 inches. Surface exposed to pressure, 6 feet 6 inches by 3 feet $5\frac{1}{2}$ inches,—equal to 22 square feet. At a pressure of 20 lbs. per square inch, or equal to 28 tons 5 cwt. 2 qrs. 24 lbs. on the whole surface, it expands in centre of plate $\frac{1}{32}$d of an inch.

		T.	C.	Q.	LBS.			
At 30 lbs.,	or =	42	8	2	8	it expanded	$\frac{1}{16}$	inch.
40	"	56	11	1	20	"	$\frac{3}{32}$	"
50	"	70	14	1	1	"	$\frac{1}{8}$	"
60	"	84	17	0	16	"	$\frac{3}{16}$	"
70	"	99	0	0	0	"	1	"
75	"	106	1	1	24	"	$1\frac{1}{4}$	"

A full $\frac{3}{8}$-inch boiler plate, flat, with a surface of 3 feet 4 inches, by 3 feet $2\frac{1}{2}$ inches, from centre to centre of rivets, expanded in centre of plate as follows:—

At a pressure of	5 lbs.	per square inch,	$\frac{3}{32}$	inch.
"	10	"	$\frac{1}{4}$	"
"	15	"	$\frac{5}{16}$	"
"	20	"	$\frac{3}{8}$	"
"	25	"	$\frac{7}{16}$	"
"	30	"	$\frac{1}{2}$	"
"	35	"	$\frac{9}{16}$	"
"	40	"	$\frac{5}{8}$	"

These results demonstrated the superiority of plates manufactured on the corrugated or indented plan. The author did not confine him-

self, in the patent which he had secured, to any particular form of indentation, nor to whether these should project on one or both sides of the plates. He simply maintained that his process imparted additional strength to ordinary plates, whilst it tested severely the quality of the metal, without waiting for the pressure of steam to do it. In one steel plate of the *John Penn*, 10 feet + 2 feet 6 inches + $\frac{3}{16}$-inch thick, 72 stays were employed; in one of his of the same dimensions, 9 such stays only would be necessary. In the back of the boiler of the same vessel, 320 stays had been used, whereas 70 would have given equal stability in the same space in a boiler of his construction.

Other facts of a similar character were mentioned by Mr. Ramsell, who illustrated his paper by drawings and models, which were handed round for the inspection of members. On the conclusion of the paper a discussion arose, Mr. Aydon taking exceptions to some of the statements made, and putting several pertinent and practical questions respecting the originality of the plans propounded. Mr. Stabler, Mr. Owbridge, Mr. Jones, and others, joined in remarks favorable or otherwise to Mr. Ramsell's views, whilst the Chairman admitted that much light had been thrown upon a very important, and, indeed, vital matter, in connexion with steam boilers, and thought that further experiments should be made as to the strength of the plates. Mr. Ramsell met all the objections, and courted further examination at his works at Deptford.—*Proc. Asso. Foremen Eng.*, May 4, 1861.

Novel Arrangement of Steam Boilers.

At the meeting of the Society of Civil Engineers of Vienna, M. Alexander Strecker communicated a very ingenious and simple mode of preventing the burning of steam boilers. This apparatus, invented by M. J. Haswell, director of the Vienna Locomotive Factory, consists in introducing into the interior of the boiler a small turbine, which continually drives the water from the bottom towards the front of the boiler: thus on the one hand cooling the walls which are most liable to overheat, and on the other facilitating the formation of steam. This arrangement, which has been tried with perfect success on a 40-horse-power boiler, has just been adapted to all the stationary boilers in the workshop of the Western Railroad.—*Cosmos.*

On Sulphur in Gas. By Alfred Kitt.

From the Lond. Jour. of Gas Lighting, &c., No. 222.

Sir,—I forward you the result of a series of experiments made on coal-gas, which will, perhaps, be of interest to some of your readers. My object in making these experiments was to ascertain the effect of furnace heat, at various temperatures, on the illuminating power of coal-gas—first suggested on reading Mr. Bowditch's correspondence in your Journal.

The apparatus I employed was (for the tube) a piece of 1-inch

tubing, connected at each end with a piece of ½-inch tube, and provided with a stop-cock. The condenser used was of glass, immersed in water; the lime-purifier was made specially for the purpose with a water-seal, and contained exactly two layers of damped cold lime, each of them 3½ inches thick. The gas-holders held 10 cubic feet each, and care was taken to have the water in the tank as clean as possible.

The tube was placed, without any material whatever inside, over the furnace, and 14-candle gas was introduced at one end, under a pressure of $\frac{3}{10}$ths. The tube was so heated as to give a temperature of 300° Fahr. to the gas at its exit from the other end of the tube. The gas, before entering the tube, was tested for sulphur, and was found not in the least to touch the lead-paper, when tested at 300° Fahr. at its exit from the tube; and, again, after passing through the condenser at a temperature of 60° Fahr., the lead paper was immediately darkened by the formation of sulphuret of lead. The gas was passed through the purifier, and perfectly cleansed of the sulphuretted hydrogen generated in the tube before entering the gas-holder. The illuminating power of the gas thus operated on was then carefully taken, when it was found to be reduced to 8·50 candles sperm. Being desirous of ascertaining the further decrease of its illuminating constituents, the same gas of 8½ candles was conducted back again through the tube at the same temperature of 300° Fahr., and condensed, and then tried with the acetate of lead-test as before, which it almost as readily darkened as at first. It was then re-purified, and stored into the other gas-holder kept for the purpose. The illuminating power being then tried for the second time, was found to be 6·75 candles sperm. The same process was repeated for a third time at the same temperature, and the lead-paper applied after condenser as before; the paper on this occasion was merely colored a light brown. After purification, it was again conducted into the gas-holder. The illuminating power was then reduced to 5·75.

The gas was thus deprived of its illuminating constituents in the following order:—

	Candles Sperm.
Illuminating power of gas employed, . . .	14
After 1st trial through tube, gas heated at 300° Fahr., and condensed to 60°, ...	8·50
" 2d "	6·75
" 3d "	5·75

The illuminating power was taken in the usual manner, with a photometer and a test-metre, and with an Argand burner consuming 5 cubic feet of gas per hour, and a spermaceti candle consuming 120 grains of sperm per hour. The result clearly proves that *heat* decomposes the volatile hydrocarbons existing in coal-gas, and, if the same gas was continued to be thus operated on, it would eventually lose its luminosity. Like experiments were made at lower temperatures, and in every case sulphur was obtained the second, third, and fourth time of trial, and a proportionate decrease in its illuminating power.

Sulphur in gas begins first to pass over and affects the lead-paper

and the solution of lead at a temperature of 110° Fahr., and continues to increase in quantity as the temperature rises. This sulphur, undoubtedly, proceeds principally from the decomposition of the volatile hydrocarbons. When the gas at the exit of tube is of the temperature of 400° to 450° Fahr., it loses just so much of its illuminating power as to reduce it to one-half; and, if the lead-paper is held for one moment in the current of the gas, it is immediately blackened. At high temperatures, the gas should be cooled through a condenser, else the test will be scorched, and will very likely mislead the operator.

In conclusion, I would observe that coal-gas, of the illuminating power of 14 sperm candles, when heated to the temperature of boiling water only, and recondensed and purified to a temperature of 60°, loses fully 20 per cent. of its illuminating quality. I have in all experiments found the like decomposition of the hydrocarbon vapors takes place, whether lime, brick-dust, or any other substance which is not chemically acted on by the agents employed, is placed in the tube.

The above experiments were made at these works, and will show to any gas engineer the impossibility, for all practical purposes, of obtaining gas utterly free from sulphur, by passing it through a heated medium.

Bath, April 15, 1861.

Chandor's Gas-Generator

Consists of a box about 1 foot high and 16 inches square in base, containing some 5 gallons of mineral oil or naphtha; a small fan moved by clock-work, stirs the liquid continually. Under the influence of a current of warm air which can be regulated at will, the mineral oil evaporates and forms a very rich and brilliant lighting-gas, burning without smoke, and in such quantity that it burns steadily at the mouth of a tube of more than an inch in diameter. It is used at present only to furnish a gas-engine, and its cost is said by Mr. Chandor (an American in Paris) not to exceed 7 centimes per cubic metre (39·65 cents per 1000 cubic feet).—*Cosmos.*

On Steam Boiler Explosions.

From the Lond. Mechanics' Magazine, April, 1861.

Mr. L. E. Fletcher, chief engineer, presented his monthly report, from which the following is abridged: During the last month, six special visits have been made, and 199 ordinary visits, making a total of 205 visits. Nine boilers have been examined specially, 504 boilers have been examined externally, 24 internally, and 21 thoroughly, making a total of 558 boilers examined. One engine has been examined especially, and 435 at ordinary visits, from 30 of which indicator diagrams have been taken. The following are some of the principal defects which have been found to exist in the aforesaid number of boilers inspected, and to which the attention of the owners has in each case been called, not only at the time of the visit, but also by a

subsequently written report:—Fracture, 10 (two dangerous); corrosion, 10; safety-valves out of order, 26 (two dangerous); water gauges ditto, 27 (three dangerous); pressure gauges ditto, 13 (one dangerous); feed apparatus ditto, 5; blow-off cocks ditto, 23; fusible plugs ditto, 4; furnaces out of shape, 10; over pressure, 1; deficiency of water, 3 (one dangerous); total, 132 (nine dangerous). Boilers without glass water-gauges, 9; without pressure gauges, 6; without blow-off cocks, 11; without feed check valves, 53. Although nothing of startling interest has occurred during the past month, still the ordinary working of this Association during that period has shown the commercial value of a regular system of boiler inspection, and thus that it has an importance entirely apart from all considerations of the saving of human life and property endangered by boiler explosions. In illustration of this, it was stated that several boilers have been met with, the proprietors of which had gone to the expense of having them fitted with brass scum and mud, or blow-out, taps, as well as the full complement of necessary mountings, and who were under the impression that these were properly attended to, and that all was done that could be to keep their boilers free from deposit, and promote their efficiency and durability; while upon inspection, however, it has been frequently found that these scum and blow-off taps have been quite neglected, and have become choked up with sediment. This has taken some of the proprietors quite by surprise, and they have felt obliged by being undeceived. Some blow-off taps are found to be quite dangerous from their construction, the shells being of cast iron and the plugs of brass, which, on account of their unequal expansion, stick as soon as they are opened, and cannot be closed again, and thus the whole of the water is blown out, the furnace crowns left dry, and the fires have to be drawn. Three tubular boilers were examined during the last month, which have been so injured as to run a stream at the tube ends and other places, mainly from the neglect of suitable blowing out, and will require a removal of all the tubes, and a large outlay upon them, before they will be again fit for use. The value of scum pipes was pointed out, not only on account of their beneficial effect on the boilers themselves, but also on the piston and slides of the engines, by preventing a quantity of earthy matter being carried over in small particles with the steam. It was stated that the water should be blown off from the surface when it is in a state of ebullition, and from the bottom when in a state of rest.—*Proc. Asso. for Prevention of Steam Boiler Explosions*, March 26, 1861.

Preparation of Nitro-Naphthaline.

Into a two-gallon glass globe, 1 kilogramme (2·2 lbs.) of common naphthaline is introduced, with 5 kilogrammes (11 lbs.) of nitric acid of commerce, and the apparatus is arranged in a bath of boiling water. The naphthaline first melts and remains swimming on the liquid; the globe is shaken from time to time, a few red vapors are disengaged,

and the oily stratum sinks to the bottom. In half an hour the operation is finished: the acid is rapidly poured off, and the oily material poured into an earthen vessel, in which it soon solidifies. At the moment of hardening it is divided by stirring it constantly, and it is washed several times to remove the excess of acid. To purify the nitro-naphthaline, it is sufficient to melt it and press it strongly after cooling; when melted it filters through paper as rapidly as water. The cakes of nitro-naphthaline are of a reddish color when in mass, but the powder is of a fine yellow. If the pressure has been sufficiently strong to squeeze out a reddish oil which impregnates the mass, the nitro-naphthaline thus prepared is very pure. Very nearly the theoretic quantity is obtained. The acid mother-waters contain various products, and especially the white bi-nitro-naphthaline, which crystallizes frequently by cooling. They contain also a large quantity of nitric acid, which is slightly tinged of a yellow color, but may be utilized.

Cosmos.

On the Temperature of the Earth's Crust, as exhibited by Thermometrical Observations, obtained during the sinking of the deep Mine at Dukinfield. By W. FAIRBAIRN, LL. D., &c.

From Newton's London Journal, June, 1861.

During the prosecution of researches on the conductivity and fusion of various substances, an opportunity occurred of ascertaining by direct experiments, under favorable circumstances, the increase of temperature in the crust of the earth. This was obtained by means of thermometers placed in bore-holes, at various depths during the sinking of one of the deepest mines in England, namely, the coal mine belonging to F. D. Astley, Esq., at Dukinfield, which has been sunk to a depth of 700 yards.

The increase of temperature in descending, shown by these observations, is irregular; nor is this to be wondered at, if the difficulties of the inquiry and the sources of error are considered, in assuming the temperature, in a single bore-hole, as the mean temperature of the stratum. At the same time, it is not probable that the temperature in the mine-shaft influenced the results. The rate of increase has been shown in previous experiments to be directly as the depth, and this is confirmed by these experiments. The amount of increase is from 51° to 57¾° Fahr., as the depth increases from 5⅔ to 231 yards, or 1° in 99 feet; but in this case the higher temperature is not very accurately determined. From 231 to 685 yards, the temperature increases from 57¾° to 75½° Fahr. This is a mean increase of 1° in 76·8 feet, which does not widely differ from the results of other observers. Walferdin and Arago found an increase of 1° in 59 feet; at Rehme, in an artesian well 760 yards deep, the increase was 1° in 54·7 feet; De la Rive and Marcet found an increase of 1° in 51 feet at Geneva. Other experiments have given 1° in 71 feet. The observations are affected by the varying conductivity of the rocks, and by the percolation of water. The author exhibited upon a diagram, in which the ordinates

are depths, and the abscissæ temperatures, the results obtained between the depths of 231 and 717 yards. The strata of the mine were also shown in section. Additional to these, the author gave a table of similar results in another pit at the same colliery, taken between the depths of 167½ and 467 yards, and showing an increase of temperature of 1° in 106 feet of descent.

Assuming, as an hypothesis, that the law thus found for a depth of 790 yards, continues to operate at greater depths, we arrive at the conclusion that at 2½ miles from the surface, a temperature of 212° would be reached; and at 40 miles, a temperature of 3000°, which we may suppose sufficient to melt the hardest rock. The author then discussed the effect of pressure and increased conductivity of the rocks in modifying this result. If the fusing point increased 1·3° Fahr. for every 500 lbs. pressure, as is the case with wax, spermaceti, &c., the depth would be increased from 40 to 65 miles before the fluid nucleus would be reached; but as the same increase is not observed with tin and barytes, the influence of pressure on the thickness of the crust cannot yet be determined. Again, Mr. Hopkins has shown that the conductivity of the dense igneous rocks is twice as great as that of the superficial sedimentary deposits of clay, sand, chalk, &c. And these close-grained igneous rocks are those which we believe must most resemble the strata at great depths. Now, if the conductivity of the lower rocks be twice as great as that of the strata in which the observations were made, correcting our former estimate, we should probably have to descend 80 or 100 miles, instead of 40, to reach a temperature of 3000°, besides the further increase due to the influence of pressure on the fusing point. On entirely independent data, Mr. Hopkins has been led to conclude that the minimum thickness of the crust does not fall short of 800 miles; in which case the superficial temperature of the crust would have to be accounted for from some other cause than an internal fluid nucleus.—*Proc. Manch. Liter. & Philos. Soc.*, April 2d, 1861.

Salubrity of Water-Reservoirs.

M. Coste, of Paris, has discovered that water-reservoirs, in order to preserve their contents wholesome, ought to be protected against heat and light. He found that the exposed reservoir killed all his young fishes. *We wish it would do the same at Fairmount.*

A New Discovery in Gas.

From the London Mining Journal, No. 1338.

The invention of Mr. Webster, of the Phœnix Chemical Works, Birmingham, is at the present moment creating considerable excitement amongst the analytical chemists and scientific men of that borough, and we are, therefore, pleased in being able to publish some of the facts connected with experiments made during the present week, as we think they will prove highly interesting to our readers. Our cor-

respondent attended on Monday evening a meeting held at the above works, at which a large number of gentlemen interested in the subject assembled. From the experiments presented, he elicited the following facts:—That the oxy-carbon gas, patented by Mr. Webster, is a combination in certain proportions of oxygen with certain parts of carbon, the particulars of which he is not at liberty to make known till the publication of the specification, which will shortly appear in this Journal. The light produced by the oxy-carbon gas is one whose purity and brilliancy almost extinguishes the flame of an ordinary gas-light or candle, which looks smoky and opaque when brought into close proximity. The new light is as 16 to 1 of ordinary gas-light. By the application of a reflector the light is thrown to a distance of 20 yards with such effect that a person is enabled to read a letter or the smallest print by it. The radiating heat is not greater than that of ordinary gas, as the oxygen, being supplied from the inner portion of the flame, does not require to partake of the inner air of the room, so that the burner is not consumed or damaged by the action of the flame in any way, but is kept comparatively cool. The oxygen can be absorbed and re-burnt as frequently as desired by a chemical process altogether original, even increasing the value of its properties pecuniarily. The new gas is obtained at a less expense than the ordinary gas, because the oxygen is less expensive by 90 per cent. than that generally employed, since $\frac{1}{4}$ of oxygen would be found equal to $\frac{1}{4}$ of carbon, although securing a register by the photometer of 30 to 1 in favor of the oxy-carbon gas over that in general use. In ordinary gas-light shown to consume 6 feet per hour, the register gives 15 candles, but in the oxy-carbon gas patented by Mr. Webster, the register shown by the photometer, is 240 candles.

Another and a peculiar feature of the new patent gas is that though the burner escapes injury from the flame, the light itself possesses a powerful heat in its centre, which will not only melt iron wire, but platinum and rubies; experiments demonstrated that iron wire twisted was instantly melted, and platinum almost as quickly, when placed in the flame emanating from a blow-pipe. To braziers, jewelers, solderers, &c., it would appear that this invention will be invaluable. Experiments were not only made with ordinary Argand burners, but with oil and paraffin lamps having wicks, each and all of which showed a similar register when the gas was applied. Mr. Webster also exhibited a lamp for light-houses, to which he demonstrated by experiment his oxy-carbon was equally applicable. We understand that Mr. Wilkins, the engineer from Trinity House, London, has been down to Birmingham to witness Mr. Webster's experiments, and that arrangements are being made for lighting up with the oxy-carbon gas the light-houses of that establishment. The apparatus of Mr. Webster is remarkably simple in its construction, so much so indeed that an ordinary person can generate the gas and arrange the light. The new gas is not explosive, and can be regulated to any extent, so as to adapt it to a private office or room, to a public building, to street light, or light-houses, and to railways and railway carriages. One

light in a public building or manufactory will be equal to sixteen ordinary gas lights; and the inexpensive character of its production will, it is asserted, reduce the expenditure of lighting at least ninety per cent. The gentlemen present appeared to be highly delighted with the successful experiments of Mr. Webster, and retired acknowledging that the light in question was all he had represented it to be, and thanking him for the demonstrations which he had kindly presented. We understand that a company is in the course of formation for the purpose of carrying out the principle of the new patent.

To Prevent Chimneys from Smoking.

A *M. de Sauges*, an architect, submits to the French Academy of Sciences a *novel plan* for preventing chimneys from smoking and increasing their draft. It consists in opening all the flues into a chamber built just under the peak of the roof; and he proposes, moreover, to put a reservoir here, so as to furnish hot water for the house.—*Cosmos.*

Extracts of Statistics of Cotton Manufacture. From the Seventh Annual Report of the Boston Board of Trade, 1861.

From the above statements we obtain the following results as to the progressive increase of the number of spindles in Massachusetts.

	Spindles.	Increase.	Per cent.
In 1831,	339,777		
1840,	624,540	284,763	83
1845,	817,483	191,143	30
1850,	1,288,091	470,608	57
1855,	1,519,527	231,436	18
1860,	1,688,471	168,944	11

From 1850 to 1860, the number had increased 400,380, being 31 per cent. upon the number in 1850, in ten years.

In the Massachusetts Statistics for 1845, the consumption of cotton is stated at 56,851,654 lbs., which, divided by the number of spindles, 817,483, gives per spindle, per year, 69·54 lbs. According to the census of 1850, the consumption is estimated at 223,607 bales, which, multiplied by 425 lbs., the average weight of bales at that time, gives 95,032,975 lbs.;—this, divided by 1,288,091, the number of spindles at that time, gives per year 73·70 lbs.

According to Massachusetts Statistics of 1855, the number of pounds of cotton was 105,851,749, which, divided by the number of spindles, 1,519,527, gives 69·66 lbs.

There is always some uncertainty about quantities stated in such reports, which are frequently furnished by estimation, rather than from actual weights and measures, which may account for the difference of the result in 1850, from the remarkable agreement in the weight at the two other periods named. This difference may be accounted for

by the circumstance that the weight of cotton is obtained, in this instance, by multiplying the number of bales by an assumed average weight per bale. I have the particular statistics from more than thirty different mills, varying from about 150 lbs. of cotton per year, on coarse goods, to about 50 lbs. per spindle on finer fabrics; so that, I think, from about 70 to 75 lbs. per spindle would be a fair average in this country.

I likewise get from those returns, where the value of the goods manufactured is given, the average value of goods per spindle.

In Massachusetts, by the "Statistics of 1845," the value was $11,164,212, which, divided by 817,483 spindles, gives for value per spindle, .	$13·65
By census of 1850, $19,712,461, divided by 1,288,091 spindles,	15·30
By Massachusetts Statistics, 1855, $24,359,212, divided by 1,519,527 spindles, ...	16·03

These results agree very nearly with the actual value derived from the accounts of several mills in Massachusetts, New Hampshire, and Maine, varying from $12·75 to $16·60 per spindle for the value of product, or cost of material and labor per year, the variation being much less than in the pounds of cotton per spindle, because where the labor is less on the coarser article, the quantity and cost of material will be more.

From a number of reports where the yards produced are stated, I obtain the following results as to the number of yards per spindle, per year:

In 1831, the yards in Massachusetts are stated at 79,231,000. Divided by the number of spindles, 339,777, the number of yards would be . . .	233 yards.
In 1845, according to Massachusetts Statistics, yards 175,682,919, spindles 817,483, . .	214 "
According to the census of 1850, the yards are given, in the United States, 298,751,392, and by the statement of De Bow, the number of spindles is 1,288,091, .	231 "
According to the census of 1850, the number of yards in New England was 596,867,507, which, divided by spindles, according to De Bow, 2,751,078, gives . .	216 "
In 1855, Massachusetts Statistics, the yards are stated at 314,996,567, divided by 1,519,527, . .	207 "

The concurrence of these results, differing only ten or twelve per cent. from the highest to the lowest, gives confidence in the accuracy of the reports.

* * * * * * *

It has been estimated that the consumption of cotton *per capita*, in England, amounts to 4¾ lbs. and to 13¼ yds. In this country,

In 1830, . . .	to 4 lbs.,	12 yards.
1840, . . .	to 7 "	21 "
1850, . . .	to 10¼ "	32¼ "

The various reports and tables I have examined give the following results, as to the number of yards per pound of cotton:

The Statistics of Massachusetts for 1845, . .	3·09 yards.
The Census of the United States, 1850, .	2·80 "
On the same authority, for the manufactures of Massachusetts in 1850, . . .	3·14 "
Statistics of Massachusetts, 1855, . .	2·97 "

As to the cost or value per yard, that is, cost of labor and material.

By Massachusetts Statistics, 1845,	6·35 cents.
Census of United States, 1850,	8·10 "
Massachusetts Statistics, 1855,	7·76 "

In 1845 it will be remembered that the price of cotton was very low.

The exportation of American Cotton Goods has increased very much during the last year, being, according to the Report of the Secretary of the Treasury upon the Finances of December 4, 1860, for

The year ending June 30, 1860,	$ 10,934,796
" " " 1859,	8,316,222
Increase,	$ 2,618,574

It is understood, that of the exports of last year, the amount of $4,200,000 went directly to China, from the ports of New York and Boston.

The exports of last year, as above, are nearly half the amount of our imports of Cotton Manufactures from Great Britain.

A late article in the Economist states the total exports of Great Britain at	£ 130,440,000
Of which cotton goods and yarn constituted	48,200,000
Of which sum the United States took	4,635,000

It is supposed that the manufacturing machinery in Great Britain has increased very rapidly for several years past. In Ellison's Handbook, p. 147, we have from the reports of the Factory Inspectors the following statements for 1850 and 1856.

	Spindles.	Looms.
1850.		
England and Wales,	19,173,969	223,626
Scotland,	1,683,093	23,564
Ireland,	119,925	1,437
	20,976,987	248,627
1856.		
England and Wales,	25,818,576	275,590
Scotland,	2,041,139	21,624
Ireland,	150,502	1,633
	28,010,217	298,847

The increase of spindles in six years would therefore be 7,033,200, or nearly 30 per cent.

If we take the same rate of increase for four years to 1860, say 20 per cent., it would be	5,602,043
Adding the number as above,	28,010,217
It would make the number in 1860,	33,612,260

and the same rate of increase would give the number of looms, 358,-615.

According to a paper read by Mr. Ashworth about a year ago, and published in the *Manchester Guardian*, the cotton consumed in Great Britain in 1850 was 629,798,400 lbs., which, divided by the number of spindles, 20,977,000, would average about 30 lbs. per spindle. He

estimates the consumption of cotton last year at 973,800,800 lbs., which at 30 lbs. per spindle would indicate the number of spindles in 1860 to be 32,460,026, being something less than the number which I derive from the per centage of increase. This estimate of 32,460,026 spindles would give an increase in ten years from 1850 of 11,483,987 spindles, or about 55 per cent. The preceding estimates for the increase in this country, in the same time, would give 726,727 spindles, or 20 per cent.

The average number of spindles to the loom is 84, being about twice the proportion in this country, which is the result of the quantity of yarn made for export, and in some degree to the extra speed of their looms.

In Ellison's Hand-book, p. 138, is an estimate of the consumption of cotton for 1856, at 920,000,000 lbs., which, divided by the number of spindles at that time, 28,010,217, would give 32·8 lbs. per spindle.

The value of the goods produced is also stated at £64,484,000, which would amount to $11·00 per spindle, being less than the average value in this country, on account of the lighter and finer quality of the goods.

We have had from time to time, for several years past, newspaper publications and calculations, to show the astonishing increase of cotton machinery in Great Britain, and estimates are made as high as ten or fifteen per cent. per annum, or, as it is sometimes stated, as many spindles per year as all we have in operation in the United States. Their machinery is no doubt increasing very fast, and during the past year probably faster than usual; but there is a great tendency to extravagance in all these estimates, sometimes founded upon verbal reports of the large number of spindles building under contract, which are all set down as completed and in operation, and sometimes on the sanguine calculations and anticipations of those whose standing and general knowledge of the business, gives confidence to their speculations.

In the Trade circular of a Manchester house, under date of February 27, 1857, there is a very elaborate statement of the increase of cotton machinery from 1850 to 1856, to show, that if the next crop of cotton in the United States did not exceed three millions five hundred thousand bales, the supply would be exhausted by the close of the year 1858, and the consequences were predicted to be such as to justify the great alarm felt by the cotton spinners. And so long ago as 1847, it was confidently predicted by Mr. Baynes, from the ratio of increase of machinery for the twelve preceding years, that the cotton required for the year 1858 would be 5,810,000 bales, of which it would be necessary that the United States should furnish 5,055,000 bales (Ellison's Hand-book, p. 136). Now it turned out that neither of the foregoing predictions were fulfilled. The crop of 1857–8, in the United States, was 3,113,962 bales, or more than 1,900,000 bales short of the number contemplated by Mr. Baynes, and yet there was no deficiency, but an increasing stock on hand at the close of the year.

These results seem to show that the increase of cotton machinery has been over-estimated by intelligent manufacturers, in years past. Yet notwithstanding the failure of these, and similar predictions, there continues to be a prevailing impression, that the increase of cotton machinery was going beyond the increase in the cultivation and production of cotton, and this opinion has been propagated with great zeal and success at the South, for the benefit of the market, and has gained such a currency in England, as to increase their alarm as to obtaining a supply for their spindles, even when there were no obstructions in their way as at present. It may be worth while to examine this subject, even though, under present circumstances no benefit may be derived from it as to the future.

The average number of bales of cotton per year, for the crop of the five years, 1856 to 1860 inclusive, appears by the yearly cotton statistics to be	3,621,715
For the five years, 1846 to 1850,	2,210,425
Increase in ten years,	1,411,290

This increase is 64 per cent.

According to the preceding statements of the increase of machinery in Great Britain, from 1850 to 1860, it was 55 per cent., and this is confirmed on the authority of Mr. Ashworth, who states the increase of the consumption of cotton in ten years, from 1849 to 1859, to be as follows:

In 1859,	973,800,800
In 1849,	629,798,400
Increase of consumption in ten years,	344,002,400

which is $54\frac{6}{10}$ per cent.

Now, taking the increase of spindles in Great Britain from 1850 to 1860, at 55 per cent., and in other parts of Europe at something less, and in this country certainly not to exceed 25 per cent., the whole increase cannot be more than 50 per cent., against an increase of the cotton crop in the same time, of 64 per cent.

After this unexpected result, the inquiry arises,—How has it happened that such a manifest error has prevailed so extensively, year after year, both in this country and in England, while no deficiency of a supply has been experienced, and the stock on hand at the end of several years has been rather increasing? This is one of the mysteries of trade, and we may sometimes see articles upon the "Supply of Cotton," and upon the "Future of Cotton," published and republished, from one side of the Atlantic to the other, that give us a glimpse of light upon the subject, and show how public opinion may sometimes be made to order.

The stock of American cotton at Liverpool is reported as follows:

	Bales.	Increase.
At close of the year 1857,	198,740	
" " " 1858,	264,810	66,070
" " " 1859,	301,000	36,190
" " " 1860,	403,000	102,000

This will confirm the foregoing calculations, and show that instead

of the machinery increasing beyond the power of the cotton crop to supply the spindles, as has been predicted for some years past, the supply of cotton has been increasing beyond the spindles.

For the Journal of the Franklin Institute.

Strength of Materials: Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 10.

SHAFTS AND GUDGEONS.

(Continued from page 42.)

SHAFTS are divided into *Shafts* and *Spindles*, according to their magnitude.

A *Gudgeon* is the metal journal or arbor on which a wooden shaft revolves.

Shafts are subjected to Torsion* and Lateral stress combined, or to Lateral stress alone.

LATERAL STIFFNESS AND STRENGTH.

Shafts of equal length have *lateral stiffness* as their breadth and the cube of their depth, and have *lateral strength* as their breadth and the square of their depths.

Hence, in shafts of equal lengths, their stiffness by any increase of depth, increases in a greater proportion than their strength.

Shafts of different lengths have *lateral stiffness*, directly as their breadth and the cube of their depth, and inversely as the cube of their length, and have *lateral strength* directly as their breadth and as the square of their depth, and inversely as their length.

Hence, in shafts of different lengths, their stiffness by any increase of their length, decreases in a greater proportion than their strength.

Hollow shafts having equal lengths and equal quantities of material, have *lateral stiffness* as the square of their diameter, and have *lateral strength* as their diameters.

Hence, in hollow shafts, one having twice the diameter of another, will have four times the stiffness and but double the strength, and when having equal lengths, by an increase in diameter they increase in stiffness in a greater proportion than in strength.

The stress upon a shaft from a weight upon it, is proportional to the product of the parts of the shaft multiplied into each other.

Thus, if a shaft is 10 ft. in length, and a weight on the centre of gravity of the stress, is at a point 2 feet from one end, the parts 2 and 8 multiplied together are equal to 16; but if the weight or stress were applied in the middle of the shaft, the parts 5 and 5 multiplied together would produce 25.

The ends of a shaft having to support the whole weight, the end which is nearest the weight has to support the greatest proportion of it, in the inverse proportion of the distance of the weight from the

* For Rules for Torsional Strength, see page 37.

end. *Hence*, when a shaft is loaded in the middle, each of the journals or gudgeons has half the weight or stress to support.

When the load upon a shaft is uniformly distributed over any part of it, it is considered as united in the middle of that part, and if the load is not uniformly distributed, it is considered as united at its centre of gravity.

When the transverse section of a shaft is a regular figure, as a square, circle, &c., &c., and the load is applied in one point, in order to give it equal resistance throughout its length, the curve of the sides becomes a cubic parabola; but when the load is uniformly distributed over the shaft, the curve of the sides becomes a semi-cubical parabola.

The deflection of a shaft produced by a load which is uniformly distributed over its length, is the same as when five-eighths of the load is applied at the middle of its length.

The resistance of the body of a shaft to lateral stress, is as its breadth and the square of its depth: *hence*, the diameter will be *as the product of the length of it and the length of it one side of a given point, less the square of that length.*

Illustration.—The length of a shaft between the centres of its journals is 10 feet: what should be the relative cubes of its diameters when the load is applied at 1, 2, and 5 feet from one end? and what when the load is uniformly distributed over the length of it?

$l \times l^1 - l^2 = d^3$, and when uniformly distributed $d^3 \div 2 = d^1$.

$10 \times 1 = 10 - 1^2 = 9 =$ *cube of diameter* at 1 foot.
$10 \times 2 = 20 - 2^2 = 16 =$ " " 2 "
$10 \times 5 = 50 - 5^2 = 25 =$ " " 5 "

When a load is uniformly distributed, the stress is greatest at the middle of the length and is equal to half of it; if collected in the middle, and when the load is uniformly distributed—

$$25 \div 2 = 12{\cdot}5 = \textit{cube of diameter at 5 feet.}$$

Cylindrical Shafts.

To Ascertain the Diameter of a Cast Iron Shaft to resist Lateral Stress alone.

When the Stress is in or near the Middle.

Rule.—Multiply the weight by the length of the shaft in feet, divide the product by 500, and the cube root of the quotient will give the diameter in inches.

Example.—The weight of a water-wheel upon a shaft is 50,000 lbs., its length 30 ft., and the centre of gravity of the wheel 7 ft. from one end; what should be the diameter of its body?

$$\sqrt[3]{\left(\frac{50{,}000 \times l}{500}\right)} = 14{\cdot}422 \textit{ ins., if the weight was in the middle of its length.}$$

Hence, the diameter at 7 ft. from one end will be, as by preceding rule, $30 \times 7 - 7^2 = 161 =$ *relative cube of diameter at 7 ft.*

$30 \times 15 - 15^2 = 225 =$ *relative cube of diameter at 15 ft.*

Then as $\sqrt[3]{225} : 14{\cdot}42 :: \sqrt[3]{161} : 12{\cdot}89$ *ins., the diameter of the shaft at 7 ft. from one end.*

When the Stress is Uniformly Laid along the Length of the Shaft.

RULE.—Divide the cube root of the product of the weight and the length by 9·3, and the quotient will give the diameter in inches.

EXAMPLE.—Apply the rule to the preceding case.

$$\frac{\sqrt[3]{50{,}000 \times 30}}{9{\cdot}3} = 12{\cdot}31 \textit{ ins.}$$

Or, *when the diameter for the stress applied in the middle is given.*

RULE.—Take the cube root of five-eighths of the cube of the diameter, and this root will give the diameter required.

EXAMPLE.—The diameter of a shaft when the stress is uniformly applied along its length is 14·422 ins. What should be its diameter, the stress being applied in the middle.

$$\sqrt[3]{\tfrac{5}{8} \times 14{\cdot}422^3} = \sqrt[3]{\tfrac{5}{8} \times 3000} = 12{\cdot}33 \textit{ ins.}$$

Hollow Shafts of Cast Iron.

When the Stress is in or near the Middle.

RULE.—Divide the continued product of ·012 times the cube of the length and the number of times the weight of the shaft in pounds by the sum of the internal diameter added to 1, and twice the square root of the quotient added to the internal diameter, will give the whole diameter in inches.

EXAMPLE.—The weight of a water-wheel upon a hollow shaft 30 ft. in length is 2·5 times its own weight, and the internal diameter is 9 ins.; what should be the whole diameter of the shaft?

$$\sqrt{\left(\frac{{\cdot}012 \times 30^3 \times 2{\cdot}5}{1 + 9^2}\right)} = \sqrt{\frac{810}{82}} = 3{\cdot}14 \textit{ ins.}$$

Then $9 + \overline{3{\cdot}14 \times 2} = 15{\cdot}28$ *ins., the whole diameter.*

To ascertain the Diameter of a Cast Iron Shaft to resist its own weight alone.

RULE.—Multiply the cube of its length by ·007, and the square root of the product will give the diameter in inches.

EXAMPLE.—The length of a shaft is 30 feet; what should be its diameter in the body?

$$\sqrt{(30^3 \times {\cdot}007)} = \sqrt{189} = 13{\cdot}75 \textit{ ins.}$$

When a Shaft has to resist both Torsional and Lateral Stress combined.

To ascertain its Diameter, the Stress being applied in the Middle.

RULE.—Ascertain the diameter for each stress, and the cube root of the sum of their cubes will give the diameter required.

EXAMPLE.—The diameter of the journal of a shaft to resist torsional stress is ascertained to be 17 ins., and the diameter of its body in the

centre to resist lateral stress, has also been ascertained to be 14·422 ins.; what should be the diameter of the body?

$$\sqrt[3]{(17^3 + 14{\cdot}422^3)} = \sqrt[3]{7913} = 19{\cdot}927 \textit{ ins.}$$

The strength of a cylindrical shaft compared to a square one, the diameter of the one being equal to the side of the other, is as 1 to 1·7, and of a square shaft to a cylindrical as 1 to ·589.

To ascertain the Diameter of Shafts of Wrought Iron, Oak, and Pine.

Multiply the diameter ascertained for cast iron as follows:

Wrought iron	by	·935
Oak	"	1·83
Yellow pine,	"	1·716

To ascertain the Deflection of a Cylindrical Shaft.

RULE.—Divide the square of three times the length in feet by the product of the following *Constants* and the square of the diameter in inches, and the quotient will give the deflection.

Cast iron,	Cylindrical shaft,	.	1500
do.	Square do.	.	2560
Wrought iron,	Cylindrical do.	.	1980
do.	Square do.	.	3360

EXAMPLE.—The length of a cast iron cylindrical shaft is 30 ft. and its diameter in the centre 15 ins.; what is its deflection?

$$\frac{\overline{30 \times 3}^{\,2}}{1500 \times 15^3} = \frac{8100}{337500} = {\cdot}024 \textit{ ins.}$$

To ascertain the Length of a Cylindrical Shaft.

RULE.—Multiply the preceding *constant* by the deflection, and the square of the diameter and one-third of the square root of the product will give the length in feet.

EXAMPLE.—The diameter of a cast iron cylindrical shaft is 15 ins. and the deflection assigned to it is ·024; what should be its length?

$$\sqrt{\frac{1500 \times {\cdot}024 \times 15^2}{3}} = \frac{90}{3} = 30 \textit{ ft.}$$

GUDGEONS.

To ascertain the Diameter of a Single Gudgeon to Support a given Stress or Weight.

RULE.—Divide the square root of the weight in pounds by 25 for cast iron, and 26 for wrought iron, and the quotient will give the diameter in inches.

EXAMPLE.—The weight on a gudgeon of a cast iron water-wheel shaft is 62,500 lbs.; what should be its diameter?

$$\sqrt{\frac{62{,}500}{25}} = \frac{250}{25} = 10 \textit{ ins.}$$

(To be Continued.)

Description of a New Optical Instrument called the "Stereotrope." By WILLIAM THOMAS SHAW, Esq. Communicated by WARREN DE LA RUE, Esq.

This instrument is an application of the principle of the stereoscope to that class of instruments variously termed thaumatropes, phantascopes, phenakistoscopes, &c., which depend for their results on "persistence of vision." In these instruments, as is well known, an object represented on a revolving disc, in the successive positions it assumes in performing a given evolution, is seen to execute the movement so delineated; in the stereotrope the effect of solidity is superadded, so that the object is perceived as if in motion and with an appearance of relief as in nature. The following is the manner in which I adapt to this purpose the refracting form of the stereoscope.

Having procured eight stereoscopic pictures of an object—of a steam engine for example—in the successive positions it assumes in completing a revolution, I affix them, in the order in which they were taken, to an octagonal drum, which revolves on a horizontal axis beneath an ordinary lenticular stereoscope and brings them one after another into view. Immediately beneath the lenses, and with its axis situated half an inch from the plane of sight, is fixed a solid cylinder, 4 inches in diameter, capable of being moved freely on its axis. This cylinder, which is called the eye-cylinder, is pierced throughout its entire length (if we except a diaphragm in the centre inserted for obvious reasons) by two apertures, of such a shape, and so situated relatively to each other, that a transverse section of the cylinder shows them as cones, with their apices pointing in opposite directions, and with their axes parallel to, and distant half an inch from, the diameter of the cylinder. Attached to the axis of the eye-cylinder is a pulley, exactly one-fourth the size of a similar pulley affixed to the axis of the picture-drum, with which it is connected by means of an endless band. The eye-cylinder thus making four revolutions to one of the picture-drum, it is evident that the axes of its apertures will respectively coincide with the plane of sight four times in one complete revolution of the instrument, and that, consequently, vision will be permitted eight times, or once for each picture.

The cylinder is so placed that at the time of vision the *large* ends of the apertures are next the eyes, the effect of which is that when the *small* ends pass the eyes, the axes of the apertures, by reason of their eccentricity, do not coincide with the plane of sight, and vision is therefore impossible. If, however, the position of the cylinder be reversed end for end, vision will be possible only when the small ends are next the eyes, and the angle of the aperture will be found to subtend exactly the pencil of rays coming from a picture, which is so placed as to be bisected at right angles by the plane of sight. Hence it follows that, the former arrangement of the cylinder being reverted to, the observer looking along the upper side of the aperture will see a narrow strip extending along the top of the picture; then, moving the cylinder on and looking along the lower side of the aperture, he

will see a similar strip at the bottom of the picture; consequently, in the intermediate positions of the aperture, the other parts of the picture will have been projected on the retinæ. The width of these strips is determined by that of the small ends of the apertures, which measure ·125 inch; and the diameter of the large ends is 1·5 inches, the lenses being distant 9 inches from the pictures. The picture-drum being caused to revolve with the requisite rapidity, the observer will see the steam engine constantly before him, its position remaining unchanged in respect of space, but its parts will appear to be in motion, and in solid relief, as in the veritable object. The stationary appearance of the pictures, notwithstanding the fact of their being in rapid motion, is brought about by causing their corresponding parts to be seen, respectively, *only* in the same part of space, and *that* for so short a time that while in view they make no sensible progression. As, however, there is an actual progression during the instant of vision, it is needful to take that fact into account—in order that it may be reduced as far as practicable—in regulating the diameter of the eye-cylinder, and of the apertures at their small ends; and the following are the numerical data involved in the construction of an instrument with the relative proportions given above:—

The circumference of picture-drum = 22·5 inches (A).

The circumference of eye-cylinder = 12 inches × 4 revolutions = 48 inches (B).

The diameter of apertures at large ends = 1·5 inch (C).

The diameter of apertures at small ends = ·125 inch (D).

While the large end is passing the eye, the picture under view progresses $\frac{1\cdot5\ (C)}{48\ (B)}$ of 22·5 (A), or ·703 inch.

This amount of progression (·703 in.), if perceived at one and the same instant, would be utterly destructive of all distinctness of definition; but it is evident that the total movement brought under visual observation at any one moment is $\frac{\cdot125\ (D)}{1\cdot5\ (C)}$ of ·703 inch, or ·058 inch.

This movement must necessarily occasion a corresponding slurring, so to speak, of the images on the retina; and the fact of such slurring not affecting, to an appreciable extent, the distinctness of definition, seems to be referable to a faculty which the mind has of correcting or disregarding certain discrepant appearances or irregularities in the organ of vision; as a further illustration of which I may cite the fact, mentioned by Mr. Warren de la Rue in his "Report on Celestial Photography," that the retinal image of a star is, at least under some atmospheric conditions, made up of "a great number of undulating points," which, however, the mind rightly interprets as the effect of the presence before the eye of a single minute object. That this corrective power is, as might be supposed, very limited, may be proved experimentally by this instrument; for if the small ends be enlarged in only a slight degree, so as to increase this slurring on the retinæ,

a very marked diminution in clearness of definition is the immediate result.

That form of the stereotrope, in which Professor Wheatstone's reflecting stereoscope is made use of, and which is better adapted for the exhibition of movements that are not only local but progressive in space, it is needless to describe here, because the principles it involves are essentially the same as those which are stated above.

Proceedings of the Royal Society, Jan. 10, 1861.

New Blasting Powder.

From the London Builder, No. 952.

Some blasting powder, made by Mr. Laurence Geoghegan, gunmaker, Galway, from tanner's waste bark, nitrate of soda, and sulphur, is spoken of by the *Galway Vindicator*. Mr. Samuel U. Roberts, Engineer to the Board of Public Works, under whose superintendence the extensive drainage works in the Galway district were carried to completion, says, in a certificate as to Mr. Geoghegan's powder: "In my presence he inserted a small quantity of it (much less than would be required of the ordinary blasting powder) into a jumper-hole 1 inch in diameter and 15 inches deep, in a very solid boulder rock of hard granite containing about 30 cubic feet. On being ignited in the ordinary manner with a fuse, it burst the rock into fragments without making a report or causing spawls to fly from it; so that a person might safely stand within a short distance without incurring danger. Mr. Geoghegan states that this powder can be sold at half the price of the ordinary blasting powder. I am of opinion that it is much stronger than that which is now generally in use for blasting purposes."

The Conduction of Heat by Gases. By G. Magnus.*

From the Lond. Engineer, No. 267.

The cooling of a body *in vacuo* depends simply on the exchange of heat by radiation between the cooling mass and the encircling envelope. If the space contains gas, an ascending current is formed, which accelerates the cooling, added to which the property which the gas has of transmitting heat, or its diathermancy, concurs in producing cooling, provided the gases can conduct heat. Dulong and Petit, in enunciating their law of the loss of heat, have neglected the last two actions, manifestly because they are infinitely small compared with the influence of the ascending currents. Since then, it has been universally admitted that the differences in the cooling of the different gases depend on the different mobility of their particles. Cooling takes place much more rapidly in hydrogen than in other gases. With the same amount of heat, this gas expands not more, but less, than atmospheric air; the changes in density in the former gas are less than the latter. But it is the difference of specific gravity which pro-

* Translated from the *Bericht der Berliner Akademie*, 1860, p. 485.

duces currents. If, therefore, different gases by contact with a warmer body all become equally heated, the currents in those gases which have a greater co-efficient of expansion must be greater than in the rest; for example, in carbonic acid more than in hydrogen. As this is not the case, it must either be assumed that the friction of the gaseous particles against each other is so great that the influence of the greater expansion is neutralized by it, which will with difficulty be admitted, or it must be assumed that gases by contact with a hot body become heated to a different extent. Such a difference in the degree of heat would take place if the gases had different capacities for heat; but as the specific heats of hydrogen and atmospheric air are the same, there remains no other explanation for the more rapid cooling in hydrogen, than that this gas can transmit heat from particle to particle, in other words, can conduct it, and that it possesses this property in a higher degree than other gases. Its low density appeared to be in disaccordance with this idea, and it appeared necessary to decide by experiments how far it is founded.

The impulse to these experiments was given by a repetition of Mr. Grove's interesting observation, according to which a platinum wire is less strongly heated when surrounded by hydrogen than by atmospheric air, or another gas. In this repetition, it was found that hydrogen exerted its preventive action even when a layer only 0·5 mil. thick surrounded the wire, and it was the same whether the tube containing it was in a horizontal or vertical position. In such a narrow tube, especially when it is horizontal, currents can scarcely occur; and when there are none, there remains no other explanation than that hydrogen conducts heat better than other bodies.

The simplest mode of ascertaining whether a gas conducts heat, consists in warming it from above, and observing the action on a thermometer placed within. It might be objected to this method that, even with heating from above, currents in the gas might be formed, and that thereby the temperature indicated by the thermometer in various gases might be different without any difference in conductibility.

There is one method of testing this objection. For if, in fact, a gas can conduct heat, the temperature assumed by a thermometer in a space heated from above must be lower when the conducting substance is wanting than when it is present; that is, it must be lower *in vacuo* than in a space filled with air.

In order to ascertain whether this was the case, a glass apparatus was used, in which a thermometer, observable from without, was firmly fixed. It could be filled with different gases, and these could be variously dilated. The upper part of this apparatus was maintained at the same temperature, namely, that of boiling water, and the temperature was observed which a thermometer introduced into the interior ultimately assumed. Of course the experiments with this apparatus were not made without numerous precautions; it was more particularly necessary that the whole apparatus should be always under the same conditions, so as to give off the heat imparted to it always in

the same manner. For this it was necessary that the space surrounding it should always be at the same temperature. In these experiments, the temperature of the surrounding space was 15°.

In this way, the following results were obtained:—1. The temperature which a thermometer ultimately assumes in a space heated from above, differs when this space is filled with different gases. 2. In hydrogen, the temperature is higher than in any other gas. 3. In this gas, the temperature is higher than *in vacuo;* and the denser the gas is, the higher is the temperature. 4. Hence, hydrogen conducts heat like metals. 5. In all other gases, the temperature is lower than *in vacuo;* and the denser they are, the lower is the temperature. 6. It cannot hence be concluded that gases do not conduct heat, but only that they do this in so small a degree that the action of conduction is cancelled by their diathermancy. 7. This remarkable property of hydrogen is evinced not only when it moves freely, but also when it is contained between eider down, or any loose substance which hinders its motion. 8. The great conductibility of this gas is a further confirmation of its analogy with metals. 9. Hydrogen conducts not only heat, but also electricity, better than other gases.

The Victoria Falls.

From the London Engineer, No. 278.

Dr. Livingstone has written a letter to Sir Roderick Murchison, giving the following corrected particulars of the great African cataract:—"The river was so low we could easily see the bottom of one-half of the fissure which forms Victoria Falls; and, indeed, people could wade from the north bank to my Garden Island, to form a stockade for fresh seeds. The depth is not 100 ft., but 310 ft.—probably a few feet more, as the weight attached to the line rested on a slope near the bottom. The breadth from bank to bank is not 1000 yards, as I conjectured in 1855, but between one statute and one geographical mile—we say 1860 yards to assist the memory, but it is a little more, yet not quite 2000 yards. The lips of the crack at Garden Island may be more than 80 ft., as we could not throw a stone across; but the sextant gave that. Now come to the other or south-eastern side of the crack, and the fissure, which from the upper bed looks like the letter L, is prolonged in a most remarkable zigzag manner. The water, after leaping sheer down 310 ft., is collected from both ends to the upright part of the letter as the escape, and then flows away on the zigzag part. The promontories formed thereby are flat at the top, and of the same level as the bed of the river above the Falls. The base of the first on the right is only 400 paces from the Fall fissure, and that on the left about 150. Their sides are as perpendicular as the Fall, and you can walk along among the trees, and by a few steps see the river some 300 ft. or 400 ft. below, jammed in a space of some 20 or 30 yards, and of a deep green color. As a whole, the Victoria Falls are the most wonderful in the world. Even now, at

extreme low water, or when it is 2 ft. lower than we ever saw it, there are 800 ft. of water falling on the right of Garden Island. And the two columns of vapor, with the glorious rainbows, are a sight worth seeing. A fall called Momba, or Moamba, below this, is interesting, chiefly because you look down it from a height of some 500 ft. It is really nothing after Mosioatunya."

New Mode of Preserving Impressions in Sand, &c.

From the London Engineer, No. 258.

The murder of President Poinsot, on the Lyons Railway, has given rise to a very ingenious plan of rendering permanent marks in sand or any other yielding soil, and which may possibly be found useful in many cases where it is desirable to preserve an impression that would otherwise be soon obliterated. The process is the invention of M. Hugoulin, an apothecary in the Imperial navy, and the manner in which it has been applied to preserve the marks made by the criminal Jud in the sandy ground of the station at Noisy-le-Sec, where he leapt from the train, is as follows:—A sheet of thin iron plate was placed over the marks made, and supported by an iron stand at a distance of about an inch and a half from the surface of the ground, a quantity of lighted charcoal was then placed on the iron plate, which soon became red-hot, and of course heated the spot over which it was placed. When the latter was raised to about 100° Centigrade (212° Fahr.), the fire, together with the plate, was removed, and a quantity of finely divided stearic acid was strewed over the impressions by means of a sieve. The powder used was that of a common *bougie*, or stearine candle, dissolved by heat in alcohol, and then thrown into a large quantity of cold water, when the stearine falls to the bottom in the form of a fine precipitate. This powder is so light and impalpable, that it is said it might be sifted over an impression in the dust of a common road without in the slightest degree interfering with the faintest mark. The instant it touched the heated surface of the ground in question, it melted, and, as it were, sealed the whole of the loose atoms into one compact mass. When a sufficient quantity of the stearine had been applied, the place was left until it had become completely cold; the surrounding earth was then dug out carefully at some little distance from the edges of the impression, and the portion containing this latter was lifted up in one entire block, and laid on a cloth several times doubled, the edges of which were raised up so as to form a kind of border, or rather framing, into which and against the sides of the sandy earth containing the impression, plaster of paris was poured, and when the latter was set, the whole could be handled without danger, and was firm enough to bear packing and carriage to any distance. It is evident, therefore, that, if necessary, it might also be used as a mould, from which casts in plaster could be obtained. The value of such a process as an aid in criminal cases is too self-evident to require demonstration; the production of the tell-tale impression in a court of laws where every mark can be conveniently exhibited and compared

with the object by which it was produced, may be equally useful in the proof of guilt and of innocence, and it would be strange indeed if a use for such a process be not discovered in matters of scientific or practical interest.—*Building News.*

The New Mortar Cannon.

From the London Engineer, No. 270.

The *Times'* Paris correspondent thus refers to this new weapon:—The tube or barrel is formed of several cylinders or rings of cast or wrought iron, its longitudinal cylindrical parts affording the means of uniting the rings. The interior of the tube is rifled by means of a certain number of projecting spiral rods shaped in triangular prisms. The tube can be lengthened at pleasure. The breech of the gun is a mortar, to which the tube is attached, and from which it may be detached, either for the purpose of loading it at the breech or of making use of it as a mortar. It is alleged that this cannon cannot become heated, that the process of cleansing after each discharge is unnecessary, except as regards the breech, and that it may be fired five times during the space now required to fire any other gun once. Another consequence said to follow from the non-heating of the barrel of the gun is, that there is no danger of bursting, either from defect in the metal or from over-charge. The gun may likewise be lengthened or shortened at pleasure. The inventor states that a gun throwing a shot of 120 pounds weight may be taken to pieces and conveyed on the back of a horse or mule over roads impassable for carriages. He shows that there is a considerable saving in the construction of this gun in consequence of the tube being of openwork, and of iron, in place of bronze. It may be as light as is consistent with the resistance which its weight must necessarily oppose to the recoil produced by its discharge. The inventor expects that this gun will supersede mortars, and that every cannon mounted on a ship's deck may be used both as a cannon and a mortar, and that a ship which carries forty guns may be said to carry forty guns and forty mortars.

On the Conversion of Iron into Steel.

From the Lond. Engineer, No. 275.

Last week M. Frémy communicated to the Academy of Sciences a second paper on his researches touching the conversion of iron into steel. Our readers will remember that in his first communication he chiefly limited himself to the question of determining the quantity of nitrogen which should be combined with iron, in order to render it convertible into good steel. M. Frémy in his second paper undertakes to prove that steel is not a carburet of iron, as has hitherto been supposed, but that there exists a series of combinations of iron with metalloids, metals, and even with cyanides, yielding steel of very good quality. He states, in the first place, that steel, when dissolved in

acids, leaves a residue different from pure carbon, but closely resembling certain cyanides. He then proceeds to show that if common iron, in its metallic state, be subjected for the space of two hours to the action of common illuminating gas (carburetted hydrogen) at a red heat, the iron is carbonized and transformed into cast iron, of a grey color, very malleable, and equal to the best specimens produced by charcoal. But if the same gas be brought into contact with nitrogenized iron (nitride of iron), then, instead of cast iron, steel is produced, the good or bad quality of which entirely depends on the quantity of nitrogen previously combined with the iron; if that quantity is sufficient, the result is steel of the finest grain. If, instead of previously nitrogenizing and afterwards carbonizing the metal, a mixture of ammonia and illuminating gas be brought into contact with common iron at a red heat, it then at once absorbs nitrogen from the ammonia, and carbon from the carburetted hydrogen, and steel is obtained of a quality corresponding to the relative proportion of the two gases. Here, therefore, the process of cementation, instead of being effected by charcoal, is accomplished by a gas proceeding from pit-coal. If, conversely, steel be heated in an atmosphere of hydrogen, it loses its nitrogen, and ammonia is produced. Hence, M. Frémy concludes that steel is not a simple carburet, but nitro-carburetted iron; and this is true, not only of steel produced in laboratories, but of the common market article. In the subsequent sitting, M. Caron, well known for his endeavors to produce good steel by the action of cyanides (combinations of cyanogen, a compound of carbon and nitrogen with other elements), made some remarks tending to show that M. Frémy was not the first to have made the discovery, but M. Frémy, in reply, distinctly claimed the priority as regarded the fact that nitrogen is an indispensable ingredient of steel.

Movement of Sea and Lake Water.

From the Lond. Engineer No. 279.

The fact that the movement of sea and lake water is confined to the surface is proved by the circumstance that while the inclination of sand (where the bottom, near the shore, is composed of that material), may be 7 horizontal to 1 perpendicular within the range of the tides and waves, it often stands at only 2 to 1, a short distance below, or at the natural slope of sand in still water. This is the case on the shore of the Lake of Geneva, near Vevay, and a similar result was observed at Cherbourg, with respect to the small materials thrown into the sea for the formation of the breakwater and which took a slope, below low water, of 1 to 1.

The co-efficient of friction of leather belts on wooden pulleys has been found to be ·47 of the pressure, and on turned cast iron pulleys ·28 of the pressure.

AMERICAN PATENTS.

AMERICAN PATENTS ISSUED FROM MAY 1, TO MAY 31, 1861.

Air Engines,—Hot	Philander Shaw,	Boston,	Mass.	28
Alarms,—Burglar	George Bruce, Sr.,	Sing Sing,	N. Y.	21
Axle Arms for Carriages,	Gottlieb Schreyer,	Columbus,	Ohio,	7
Balloons,	Mortimer Nelson,	City of	N. Y.	21
Barrel,	S. Roberts,	Cleveland,	Ohio,	14
Bathing Appar.,—Electro-mag.	James Young,	City of	N. Y.	14
Bed Spring,	W. C. Cook,	Appleton,	Wis.	21
Beehives,	T. P. Hornbrook,	Wheeling,	Va.	21
———	F. R. Walker,	Waterford,	Penna.	7
Bees,—Device for Hiving	Calvin Cutler,	Tonawanda,	N. Y.	21
Bells,—Stringing Sleigh	L. C. Chase,	Boston,	Mass.	14
Berries,—Basket for	S. R. Wilmot,	Brooklyn,	N. Y.	14
Blind Fastening	W. C. Hicks,	Boston,	Mass.	21
Bolt and Rivet Machine,	Abraham Reese,	Pittsburgh,	Penna.	21
Boot Legs,	C. H. Leffingwell,	Providence,	R. I.	14
Boots and Shoes,	Denis Lenain,	City of	N. Y.	14
Boring Machine,	N. R. Merchant,	Gifford,	"	28
Brace,—Ball	H. S. Bartholomew,	Bristol,	Conn.	21
Brakes,—Wagon	J. S. Whisler,	Albany,	Ill.	21
Bridges,—Suspension	Joseph Tomilson,	Putnam,	Iowa,	28
Broom,	Langdon & Kellogg,	Quasqueton,	"	14
———	C. Weitman,	Independence,	"	14
——— Clasp,	Nelson Homes,	Leona,	N. Y.	14
Burial Cases,	J. H. Weaver,	Baltimore,	Md.	7
Buttonhole Cutters,	I. J. Fearing,	S. Weymouth,	Mass.	14
Callipers,	J. H. Call,	Springfield,	Mass.	28
Capstans,—Portable	George Cook,	Bristoe Station,	Ill.	28
Capstan and Windlass,—combin.	John S. Getchell,	Machias,	Me.	14
Carding Machines,	S. R. Parkhurst,	City of	N. Y.	21
Carriages,	C. B. Wood,	"	"	14
———,—Wheel	Goodhue & Carey,	Cincinnati,	Ohio,	14
Cartridge,—Waterproof	Roberts Bartholomew,	U. S. Army,		21
Chair Backs,—Cutting	J. A. Dyer,	Newburgh,	Ohio,	21
Children's Carriages,	Charles Askam,	Philadelphia,	Penna.	14
Churn,	Jackson & Clarke,	Syracuse,	N. Y.	7
———	John Stillwell,	Griffin,	Ga.	21
Cigar Machines,	Julius deBary,	Offenbach,	Germ'y,	28
Coal Oil,—Distilling	G. W. Hirchhoffer,	Cincinnati,	Ohio,	21
Copying Presses,	C. Y. Heackler,	Philadelphia,	Penna.	21
Cork Extractor,	E. A. Burgess,	New Haven,	Conn.	21
—— Fastener for Bottles,	Daniel Miller,	Marietta,	Ohio,	14
—— Pull,	W. C. Wyckoff,	Brooklyn,	N. Y.	21
Corn Planters,	Aaron Colton,	Attica,	"	28
———	H. J. Howe,	Onarga,	Ill.	14
—— Shellers,	Bundy & Edgerson,	Hyde Park,	Vt.	14
Cotton Press,	W. P. Craig,	Newport,	Ky.	7
Cultivators,	Cone & Potter,	Oneida,	Ill.	28
———	Ira Cooper,	Saybrook,	Ohio,	14
———	G. W. Hildreth,	Lockport,	N. Y.	21
———	Mumford & Wilson,	Clarksburgh,	Ohio,	28
———	Joseph Vowles,	New Hudson,	Mich.	21
———	W. S. Weir, Jr.,	Monmouth,	Ill.	28
Distillation,—Method of	Van Buren Ryerson,	City of	N. Y.	7
Drawing Frames,—Stop Motion	H. G. Williams,	Warren,	R. I.	21
Dust Pan,	G. H. Horstman,	Philadelphia,	Penna.	21

Electric Machine,—Frictional	Robert Cornelius,	Philadelphia,	Penna.	21
Electrophorus, .	" .	"	"	21
Elevators, .	Otis Tufts, .	Boston,	Mass.	28
Erasers, .	James M. Hicks, .	"	"	14
Field Bucket, .	George Wood, .	Strasburg,	Penna.	14
Filter,—Portable .	H. A. Hall, .	Boston,	Mass.	21
Fire Arms, .	Albert V. Hill, .	Carrollton,	N. Y.	28
——— (2 patents),	J. H. Merrill, .	Baltimore,	Md.	28
———-,—Magazine	Lorenzo Sibert, .	Mt. Solon,	Va.	14
———,—Revolving .	C. R. Alsop, .	Middletown,	Conn.	14
—— Extinguish. appar.,—Ship's	J. L. Stuart, .	City of	N. Y.	21
—— Place Heater, .	F. L. Hedenberg, .	"	"	21
—— Places, .	Gauson & Coit, .	Buffalo,	"	14
Flour,—Cooling and Drying	Park & Staats, .	Somerville,	N. J.	28
Furnaces,—Steam Boiler	J. R. Robinson, .	Boston,	Mass.	14
Gaiters,—Congress .	H. S. Holmes, .	Lynn,	Mass.	14
Gas Appar.,—Portable Water	Charles Harasythy,	San Francisco,	Cal.	21
— Regulators, .	Thomas Powers, .	Philadelphia,	Penna.	14
Gates,—Approach Opening	R. Brinkerhoff, .	Mansfield,	Ohio,	28
Grain Separators, .	Charles B. Martin, .	Fond du Lac,	Wis.	28
——— .	J. A. Scott, .	Rochester,	N. Y.	28
Grinding,—Making Maize Fit for	S. P. McCroskey, .	Monroe,	Iowa,	28
Guano,—Sowing .	S. B. Black, .	Harrisburg,	Penna.	28
Harvesters, .	Ira Jewell, .	Wheaton,	Ill.	21
——— .	Frederick Landon,	Brockport,	N. Y.	28
——— .	J. S. Marsh, .	Lewisburg,	Penna.	21
——— .	James Pine, .	Troy,	N. Y.	7
——— .	C. P. Wing, .	Fayetteville,	"	28
———,—Clover	Frederick Decker,	Ostrander,	Ohio,	28
———,—Rakes for .	James Pine, .	Troy,	N. Y.	7
———,—Raking Attach.	A. B. Smith, .	Clinton,	Penna.	14
Hat Bodies,—Forming .	G. and C. Beatty, .	Norwalk,	Conn.	21
Hay,—Turning and Spreading	E. W. Bullard, .	Barre,	Mass.	21
Heating Apparatus, .	Ambrose Kohler, .	Boston,	"	28
Hoes,—Manufacture of	Walter Baker, .	W. Winstead,	Conn.	21
——,—Handles to .	W. T. Clement, .	Northampton,	Mass.	14
Honeycomb,—Artificial	Samuel Wagner,	York,	Penna.	7
Hook for Nautical Use,—Detach.	John Brooke, .	U. S. Navy,		28
Horse shoes,—Calks for	J. H. Jennings, .	New Bedford,	Mass.	21
Hose Pipes,—Valves for .	John M. deBolle, .	Philadelphia,	Penna.	28
Hydrants, .	Joseph Neumann,	"	"	14
Iron Buildings,—Constructing	S. J. Seely, .	Brooklyn,	N. Y.	7
—— Ore,—Furnaces for Smelt'g	Patrick Kerr, .	NewBethlehem,	Penna.	28
——,—Manufacture of Sheet	W. D. Wood, .	Wilmington,	Del.	14
—— Vessels,—Construction of	S. J. Seely, .	Brooklyn,	N. Y.	21
Irrigating Streets, .	J. P. Ellicott, .	Washington,	D. C.	14
Journal Boxes, .	D. H. Dotterer, .	Memphis,	Tenn.	7
Knitting Machines, .	Joseph Dalton, .	Brooklyn,	N. Y.	7
———	S. W. Howland,	Adams,	Mass.	14
Lamps, .	W. Freeman, .	Mt. Carmel,	Conn.	21
——— .	Frederick Heidrich,	Philadelphia,	Penna.	7
——— .	Walter Hunt, .	City of	N. Y.	21
Latch Bolts, .	John Adt, .	Waterbury,	Conn.	14
——,—Thumb .	John Range, .	Meriden,	"	14
Locks, .	Moses Ducharme,	Cohoes,	N. Y.	14
——— .	J. J. Hirsbuhl, .	Louisville,	Ky.	14
——— (2 patents,)	Linus Yale, Jr.,	Philadelphia,	Penna.	14
Locomotion,—Apparatus for	Elisha Matteson, .	Brooklyn,	N. Y.	28

Looms,	Graichen & Hoffman,	Clinton,	Mass.	7
———	Alexander Frey,	City of	N. Y.	7
———,—Let-off Motion for	Renssalaer Reynolds,	Stockport,	"	21
Man-power,—Application of	T. W. Hoskings,	Detroit,	Mich.	21
Milk Can,	Philip Teets,	City of	N. Y.	28
Milking Cows,	M. L. Baker,	Milford,	"	21
———————,—Device for	W. D. Nichols,	Davenport,	Iowa,	21
Mining Picks, &c.,—Making	Elisha Hughes,	McCartysville,	Cal.	7
Mowing Machines,	Henry Fisher,	Alliance,	Ohio,	7
Nail Machine,	E. G. Hall,	City of	N. Y.	7
Ordnance,	T. J. Mayall,	Roxbury,	Mass.	21
———,—Projectile for Rifled	B. B. Hotchkiss,	Sharon,	Conn.	14
———,—Vent-stoppers of	J. J. Hirschbuhl,	Louisville,	Ky.	28
Paint Cans,	J. F. Drummond,	City of	N. Y.	21
Photographic Albums,	Anthony & Phœbus,	"	"	28
———————	F. R. Grumel,	Geneva,	Switz.	14
Pianoforte Actions (2 patents),	Henry Steinway, Jr.,	City of	N. Y.	21
Picker Motion,	Wm. Nugent,	Chicopee,	Mass.	14
Pipe,—Casting	Samuel Fulton,	Conshohocken,	Penna.	21
Pipes,—Hydraulic Cement	Henry Knight,	Jersey City,	N. J.	14
Platforms,—Extension	Andrew Morse,	Portland,	Me.	7
Ploughs,	Thomas Patterson,	Rush,	Ill.	14
———,—Steam	Shotwell & Hicks,	Ottawa,	"	28
Portfolios for Music, &c.,	J. C. Koch,	City of	N. Y.	21
Pressure Indicator,—Hydrostatic	J. E. Wootten,	Philadelphia,	Penna.	14
Printing Presses,	G. R Dean,	Mayville,	N. Y.	7
Puddling & Refining Furnaces,	S. M. Fales,	Baltimore,	Md.	14
Pumps,	H. G. Crowell,	Roxbury,	Mass.	21
———	J. M. May,	Janesville,	Wis.	7
———	W. E. Watters,	East Bend,	Ky.	7
———,—Rotary	Jones & Rider,	City of	N. Y.	21
Punch'g & Perforat. Paper, &c.,	G. C. Howard,	Philadelphia,	Penna.	21
Railroad Cars,—Running Gear of	Sebre Howard,	Elyria,	Ohio,	28
Railroads,—City	W. C. Grimes,	Philadelphia,	Penna.	14
Railways,—Permanent	Robert Watson,	Chatham,	Ill.	14
Rain Gutters,—Beading	Wm. H. Henderson,	Franklin,	Ind.	28
Rakes,—Horse	Samuel Mowry,	Whomelsdorf,	Penna.	14
Roofing,—Mastic Composit. for	C. C. Hoff,	Poughkeepsie,	N. Y.	14
——— with Slate,—Mode of	J. S. Sammons,	City of	"	21
Sad Iron,	Wm. McClure,	Peebles,	Penna.	14
Saw Mills,	Wm. M. Ferry, Jr.,	Ferrysburg,	Mich.	28
Sawing Machines,—Feeding	Jesse Gilman,	S. Merrimack,	N. H.	28
Seed Drills,	J. S. Marsh,	Lewisburg,	Penna.	14
———	Jacob Strayer,	Miamisburg,	Ohio,	14
Seeding Machines,	H. R. Stover,	Lancaster,	Penna.	14
Sewer Inlets,	Strickland Kneass,	Philadelphia,	"	21
Sewing Machines,	Samuel Comfort, Jr.,	Morrisville,	"	7
———————	Lewis Cooper,	Philadelphia,	"	28
———————	Jones & Hanghain,	Brooklyn,	N. Y.	14
———————	J. P. Sherwood,	Fort Edward,	"	14
———————	L. H. Smith,	Salem,	N. J.	21
———————	J. W. Stoakes,	Milan,	Ohio,	28
———————	M. G. Wilder,	Meriden,	Conn.	14
Shafting,—Hangers for	M. H. Mansfield,	Ashland,	Ohio,	14
Signal Lanterns,—Railroad	N. A Menaar,	Buffalo,	N. Y.	21
Skates,	Goodyear & Sprague,	Binghamton,	"	21
———	N. C. Sandford,	Meriden,	Conn.	28
Sled Brake,	A. S. Clark,	Dryden,	N. Y.	21
Smelting & Refining Furnaces,	S. M. Fales,	Baltimore,	Md.	14

Springs,—Making Upholstery	C. A. Young,	Provi lence,	R. I.	21
Steam Boilers,—low water alarm	W. H. Miller,	Philadelphia,	Penna.	14
—— Cock,	Thomas Sanford,	Claremont,	N. H.	14
Steering Apparatus,	J. McCausland & others,	Rondout,	N. Y.	14
———————	Richard F. Joynes,	Bristol,	R. I.	28
Stoves,	Treadwell & Hailes,	Albany,	N. Y.	7
Sugar,—Breaking	Joseph Forrest,	City of	"	14
Telegraphic Apparatus,	G. M. Phelps,	Williamsburg,	N. Y.	28
Thimble Boxes,—Casting	J. G. Holt,	Chicago,	Ill.	7
——— Skeins,—Patterns for	E. F. Hurlbut,	"	"	21
Thread,—Winding	J. A. Bradshaw,	Lowell,	Mass.	28
Threshing Machines,	S. E. Oviatt,	Richfield,	Ohio,	14
Time Tell-tale,	Henry Maule,	Philadelphia,	Penna.	14
Tin Foils,—Manufacture of	J. J. Crooke,	City of	N. Y.	21
Tire,—Upsetting	Benjamin Upton,	Elyria,	Ohio,	21
Tops,—Children's Flying	Henry Benton,	Guilford,	Conn.	14
Traps,—Animal	John Quigley,	Winona,	Minn.	28
Trusses,	Gordon & Dunn,	Albany,	N. Y.	7
Valves,	Daniel Minthurn,	Beverly,	Mass.	28
Vapors,—Disseminat. Medicated	J. W. Smith,	Iowa Point,	Kansas,	21
Vegetable Cutter,	Earl Guyer,	Wolcott,	Vt.	7
Washing Machine,	John D. Cochran,	Milford,	N. H.	28
———————	J. and A. H. Doty,	West Falls,	N. Y.	28
———————	C. O. Luce,	Brandon,	Vt.	14
———————	L. L. Miller,	Jersey Shore,	Penna.	14
———————	J. S. Peaslee,	Providence,	R. I.	7
———————	Stephens & Buell,	City of	N. Y.	28
———————	J. N. Wilson,	Mt Bethel,	Penna.	14
Water Elevators,	C. Bixler,	Rogersville,	Ohio,	21
———————	George Murray,	Cleveland,	"	14
—— Wheels,	J. B. Caldwell,	Chambersb'h,	Penna.	28
Weather Strips,—Adjustable	O. B. Scofield,	E. Stoughton,	Mass.	28
Weighing Sacks,	Henry Winter,	Hackney,	Engl'd,	14
Wheels,—Annealing Car	A. L. Mowry,	Cincinnati,	Ohio,	7
Wheelwright's Machine,	N. T. Edson,	New Orleans,	La.	14
Window Shade,	J. W. Ogle,	Concord,	Ill.	28
Windlasses,	Edwards & Horner,	City of	N. Y.	7
Wind Wheel,	Jacob Maag,	Milwaukie,	Wis.	28
Wool, &c.,—Machines for Drying	Benjamin James,	Worcester,	Mass.	28
Wrenches,	G. B. Phillips,	Newark,	N. J.	28
Zinc for a Paint,—Oxide of	Charles Titterton,	Rohampton,	Gr. Brit.	14

EXTENSIONS.

Screws,—Cutting	P. W. Gates,	Chicago,	Ill.	14
Wheels for Railroad Carriages,	A. Atwood (3 patents),	Troy,	N. Y.	14

RE-ISSUES.

Cartridge Cases,—Metallic	Edward Maynard,	Washington,	D. C.	28
Cheese,—Manufacture of	Redington & McCluer,	Fredonia,	N. Y.	21
Furnaces,—Steam Boiler	J. R. Robinson,	Boston,	Mass.	14
Harvesters (4 patents),	G. M. Selden,	Troy,	N. Y.	7
Horse Power,	Brayley & Pitts,	Buffalo,	"	14
Hose Coupling,	Emerson Gaylord,	Chicopee,	Mass.	21
Kettles,—Making Brass	F. J. Seymour,	Waterbury,	Conn.	14
Planing Machines,—Wood	H. D. Stover,	City of	N. Y.	21
Reaping Machines,	W. H. Seymour & others,	Brockport,	"	7
Ship Building,	R. F. Loper,	Philadelphia,	Penna.	7
Steam Hammer,	R. R. Taylor,	Reading,	"	21
Water Wheels,	H. G. Nelson,	Mexico,	N. Y.	21
Winch,—Direct & Counter Mot.	Charles Perly,	City of	"	21

DESIGNS.

Carpet (11 cases),	H. G. Thompson,	City of	N. Y.	7
Curtain Loops,	Edward Maynard,	Brooklyn,	"	28
Hats,	J. J. Morrisett,	City of	"	28
———	S. R. Hawley,	"	"	28
Pumps,	Miles Greenwood,	Cincinnati,	Ohio,	28
Skirt,—Balmoral	C. M. Cooke,	Waterloo,	N. Y.	28
Stoves,	M. C. Burleigh,	Somersworth,	N. H.	28
———	Smith & Brown,	Philadelphia,	Penna.	28
Stove,	S. W. Gibbs,	Albany,	N. Y.	7
———,—Cook	N. S. Vedder,	Troy,	"	28
Stoves,—Cooking	Smith & Brown,	Philadelphia,	Penna.	14
Stove,———	S. W. Gibbs,	Albany,	N. Y.	7
Stoves,———	C. W. Palmer,	Troy,	"	7
Stove,—Parlor	S. W. Gibbs,	Albany,	"	7
———	"	"	"	28
Tea-pot,	Hiram Young,	City of	"	7
Trade Mark,	A. F. Johnson,	Boston,	Mass.	28
———,—Label or	I D. Brewer,	Cambridge,	"	28

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, July 18, 1861.

John Agnew, Vice President, in the chair.
Frederick Fraley, Corresponding Secretary. } Present.
Isaac B. Garrigues, Recording Secretary. }

The minutes of the last meeting were read and approved.

Donations to the Library were presented by the Zoological Society, London; la Société Industrielle de Mulhouse, and l'Ecole des Mines, Paris, France; de Niederosterreichischen Gewerbe-Vereines, Vienna, Austria; Messrs. F. H. Storer and Charles W. Elliot, Boston, Mass.; and Dr. S. S. Garrigues and Prof. J. F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of June was read.

The Board of Managers and Standing Committees reported their minutes.

Two candidates for membership in the Institute were proposed.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

RAIN AND CLOUDS.—In former articles* I have given somewhat minutely my observations on the atmospheric pressure, and on the temperature of Philadelphia, for a period of nine and a half years, up to the end of December, 1860. The following table shows the quantity of rain and melted snow that fell during the same period.

* See Journ. Frank. Inst., present series, vol. xli., pages 64 and 351.

TABLE I.—*Amount of Rain and melted snow, in inches, which fell at Philadelphia, from July, 1851, till December, 1860, inclusive.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Mean.
January,		2·010	1·840	2·320	2·601	3·368	2·989	2·686	5·210	3·351	2·933
February,		2·710	4·440	4·200	2 480	1·128	0·921	2·393	3·569	2·724	2·729
March,		4·270	2·460	1·625	1 979	2·039	1 773	1·124	6·503	1·323	2·566
April,		6·440	3·880	8·145	2·148	3 149	6·932	4·681	5·068	3·646	4·965
May,		3·040	5·170	7·299	3·033	2·354	6·043	5·308	1·946	3 589	4 196
June,		4·500	1·050	3·441	8·008	1·677	7·426	4·205	5·229	3·706	4 360
July,	4·360	4·060	8·630	3·837	6·594	1·127	3·373	1·454	3·915	0·851	3·820
August,	3·420	4·400	3·080	0 918	3·237	5·186	8·039	5·157	4·447	9·260	4·714
September,	3·600	1·290	4·460	4·883	4·129	5·702	1·132	1·589	7·779	2·907	3·747
October,	3·038	2·250	3·470	1·918	3·416	1 303	2·742	1·778	3·210	4·685	2 781
November,	3·410	6 050	2·320	3·460	2·022	2·886	1·575	5·225	3·796	6·057	3·680
December,	1·880	5·180	2·165	3·185	5 006	3·619	5 503	5·459	3·460	3·301	3·976
Annual totals,		46·200	42·965	45·231	44·653	33·518	48·448	41·059	54·752	45·400	44·692
Winter,		6·600	11·460	8 685	8·266	9·502	7·529	10·582	14·258	9·535	9·602
Spring,		13·750	11·510	17·069	7·160	7·522	14·748	11·113	14·117	8·558	11·727
Summer,		12 960	12·760	8·196	17 839	7·990	18·838	10·816	13·591	13·817	12 979
Autumn,	10·048	9·590	10·250	10·261	9·567	9·891	5·449	8·592	14·785	13·049	10·208

Table II. contains the number of days on which rain or snow fell in such quantity as could be measured.

TABLE II.—*Number of days in each month from July, 1851, till December, 1860, on which rain or snow fell, at Philadelphia.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Mean.
January,		9	5	11	11	11	12	9	10	8	9·6
February,		12	12	10	7	7	8	10	14	8	9·8
March,		14	11	10	8	11	9	8	14	8	10 3
April,		15	12	14	9	14	14	15	13	15	13·4
May,		10	15	15	8	12	12	18	11	19	13·3
June,		12	6	9	17	10	17	10	12	10	11·4
July,	11	9	14	9	9	9	12	10	11	10	10·4
August,	8	13	11	9	11	9	10	10	8	13	10·2
September,	10	6	8	6	11	7	9	6	11	7	8·1
October,	10	7	7	9	11	6	8	9	7	13	8·7
November,	11	15	11	7	7	9	11	12	8	12	10·3
December,	10	15	8	11	13	6	12	14	10	8	10·7
Annual totals,		137	120	120	122	111	134	131	129	131	126·1
Winter,		31	32	29	29	31	26	31	38	26	30·3
Spring,		39	38	39	25	37	35	41	38	42	37·1
Summer,		34	31	27	37	28	39	30	31	33	32·2
Autumn,	31	28	26	22	29	22	28	27	26	32	27·1

The amount of sky covered by clouds is estimated, as near as may be, at the time of each observation, and entered on the record as so many tenths covered. In the following tables, these amounts have been changed into hundredths, and entitled so much per cent. covered. If the sky is entirely covered, it is marked 100 per cent., if half covered, 50, &c. Table III. shows the comparative quantity of sky covered at the different hours of observation. It will be seen, as might be expected, that as the temperature of the day decreases, the quantity of moisture condensed in the form of clouds also decreases.

TABLE III.—*Amount of sky covered with clouds at 7 A. M., 2 P. M., and 9 P. M., as determined by estimated observations, extending from July, 1851, till December, 1860, at Philadelphia.*

Months.	7 A. M.	2 P. M.	9 P. M.	Monthly Mean.
	Per ct.	Per ct.	Per ct.	Per ct.
January,	61	62	45	56
February,	61	59	43	54
March,	58	59	41	53
April,	64	65	53	61
May,	60	60	48	56
June,	57	60	44	53
July,	56	56	39	51
August,	54	59	41	51
September,	54	50	34	46
October,	54	54	39	49
November,	60	59	52	57
December,	65	64	48	59
Hourly Means,	58·7	59·0	43·9	53·9
Winter,	63	61	45	56
Spring,	61	62	47	57
Summer,	56	59	41	52
Autumn,	57	54	41	51

The average amount of cloudiness for a day is obtained by taking the mean of the estimated amount for the three observations; and for a month by finding the average of the daily means. The comparative cloudiness of each month of the year, obtained in this manner, is shown in the fourth table.

TABLE IV.—*Showing the comparative cloudiness of each month and season, from July, 1851, till December, 1860, inclusive, at Philadelphia.*

Months.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	Mean.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
January,		45	50	63	63	54	53	58	57	60	56
February,		45	61	51	59	58	47	56	61	49	54
March,		57	53	51	67	48	52	41	55	52	53
April,		62	63	68	60	59	56	64	60	54	61
May,		46	52	48	60	57	55	70	49	69	56
June,		41	44	51	66	58	64	51	56	50	53
July,	47	41	56	48	60	49	63	43	48	50	51
August,	43	57	51	50	58	50	51	55	49	53	51
September,	38	31	45	53	47	45	54	35	61	49	46
October,	36	47	39	44	54	47	66	49	54	59	49
November,	56	58	66	56	66	48	47	66	51	58	57
December,	53	63	48	61	67	49	56	70	65	60	59
Annual means,		49	52	54	60	52	55	55	55	55	54
Winter,		48	58	54	61	60	50	57	63	58	56
Spring,		55	56	56	62	55	54	58	55	58	57
Summer,		46	50	50	62	52	59	49	51	51	52
Autumn,	43	45	50	51	56	47	56	50	55	55	51

JUNE.—The mean temperature of the month of June differed less than half a degree from the mean temperature of the month for the last ten years; it was, however, higher by a degree and a half than that of June last year.

The warmest day of the month was the 23d, of which the mean temperature was 82·8°. The thermometer was highest (91°), however, on the 15th, of which the mean temperature was 82·3.

The coldest day was 6th, of which the mean temperature was 55°. The thermometer indicated the lowest temperature (51°) on the same day.

The greatest daily oscillation, or change of temperature in the course of one day, was 29° on the 10th. The least daily oscillation was 8° on the 6th, when rain fell nearly all day. The average oscillation for the month (18·55°) was half a degree less than for June, 1860, but two degrees greater than the average for June for ten years past.

The greatest daily range of temperature—that is, the greatest mean difference of temperature between two successive days—was 12½° between the 16th and 17th; the least was $\frac{8}{10}$ of a degree between the 13th and 14th. The average daily range for the month was 5·29°, which was one degree greater than for June last year, and about half a degree greater than the average for the month for ten years.

The atmospheric pressure was greatest (30·062 inches) on the morning of the 1st, and least (29·529 inches) on the evening of the 21st, but the mean daily pressure was least (29·563) on the 16th of the month and greatest (30·004) on the 1st. The mean pressure at 7 A. M. and 2 P. M. was about two-hundredths of an inch greater than for the same hours for June of last year, and about four-hundredths of an inch less than the average for ten years; but at 9 P. M. it was about six-hundredths of an inch less than the average and nearly one-hundredth of an inch less than for the same hour of June, 1860. This month presents the only instance that I have on record of the average atmospheric pressure, for a whole month, being less at 9 P.M. than at 2 P. M. According to analogy, the mean pressure at 9 P. M., for the month of June last, should have been 29·759 ins., just two-hundredths of an inch more than it actually was.

The greatest mean daily range of pressure for the month was 0·243 of an inch, and occurred between the 14th and 15th; the least was 0·023 of an inch between the 18th and 19th; and the average for the whole month was 0·104 of an inch, which was seven-thousandths of an inch greater than usual.

The force of vapor was greater than for June of last year, but less than the average for ten years.

The relative humidity was less at 7 A. M. and greater at 2 P. M. and 9 P. M. than it was during June, 1860. It was considerably less than the average at 7 A. M., a little less at 2 P. M., and just the same as the average at 9 P. M. for the last ten years. The anomaly in this case appears to correspond in some degree with that of the pressure of the atmosphere.